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Communications Data for Tank Battalions: Ft Stewart, Ga.

by

Charles B. Lennahan

December 1960

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INTELLIGENCE DIVISION
Technical Paper ORO-TP-13
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Charles B. Lemahan



OPERATIONS RESEARCH OFFICE
The Johns Hopkins University Bethesda, Maryland

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PROBLEM

To analyze the tape-recorded communications traffic acquired by monitoring the battalion command nets of the 3d and 4th Med Tk Bns during three exercises at Ft Stewart, Ga., in the fall of 1959.

FACTS

The objective of Study 42.6 is to determine the minimum or critical communications requirements for a future field army; this work has centered around the war games of the Intelligence Division Gaming Operation (INDIGO). An analysis of communications traffic from actual field exercises is valuable as a check on the results obtained from the games. Teams were sent on three occasions in the fall of 1959 to monitor the exercises at Ft Stewart, Ga. This paper represents the results of an analysis of the data obtained from the communications tape recordings that were made on these trips.

DISCUSSION

The tape recordings of the radio communications necessary for the effective operation of the battalions were transcribed in detail. These transcriptions yielded link, message-function, and messages-per-conversation data. The range determinations were made chiefly from a series of photographs of the operations overlays taken at intervals during the exercises. The data were inadequate for determining a complete frequency distribution for the Bn HQ ↔ Tk Co ranges; however, the extreme ranges in each of the exercises were determined.

The operations orders, transcriptions, and photographs of the overlays were used to prepare the general description of the tactical aspects of each exercise; this description is included in the section dealing with the exercise. Additional descriptive material relating to the environment in which these exercises were carried out is also provided to facilitate comparing the communications results from Ft Stewart with those of similar operations and simulations. The communications results for the Tk Gp ↔ Tk Co link in the first play of INDIGO are included in the final section of this paper. No organizations similar to the tank battalion were played in the second and third INDIGO games (see App A for combat organization).

SUMMARY

In comparing the results presented in this paper it should be noted that the first exercise was a command post exercise (CPX) in which only the command elements were in the field; the second and third exercises were field training exercises (FTX) involving medium tank battalions. The monitoring of the battalion command nets in each exercise yielded approximately 15 hr of recorded traffic for the first exercise, 36.5 hr for the second, and 35.5 hr for the third. In each exercise there were intervals, usually in the late evening and early morning hours, when the operations ceased. These periods of nocturnal inactivity account for most of the gaps in the recorded coverage of the exercises. The time occupied by the changing of tape reels and periods of heavy static is considered insignificant.

Observations

- (1) For the Bn ↔ Tk Co links at Ft Stewart there was an average of 3.6 conversations*/link/hr.
- (2) The transcribed data for the three exercises show an average of 10.9 critical messages†/hr on the Bn ↔ Tk Co type-link. The INDIGO I Tk Gp ↔ Tk Co figure is 12.4 critical messages/hr.
- (3) The field exercises showed an average of 2.9 critical messages/link/hr; the INDIGO Tk Gp ↔ Tk Co results showed 2.3 critical messages/link/hr.
- (4) The CPX results showed an average of 1.3 messages/conversation; the second and third exercises had 1.5 messages/conversation.
- (5) The maximum Bn Hq ↔ Tk Co range observed in the photographs of the overlays of the field exercises was 12 km; approximately 90 percent of the ranges were ≤ 10 km. The maximum noted in INDIGO I for a Tk Gp ↔ Tk Co link was 26 km; however, for one of the two tank groups employed as a group, 90 percent of the ranges were ≤ 17 km, and for the second group approximately 90 percent were ≤ 14 km.
- (6) For the three field exercises the message content of approximately 24 percent of the recorded conversations were unintelligible to the transcriber; most of these messages were probably unintelligible to the receiver also.
- (7) In the three exercises a total of 2492 conversations were counted; of these, 591 (24 percent) contained no intelligible messages (Observation 6). The remaining 1901 conversations contained messages that could be understood by the transcriber; 60 percent of these contained one message, 26 percent contained two, 9 percent contained three, and 4 percent contained four messages. The largest number of messages in a single conversation was seven.

* A conversation was considered to be continuous verbal exchange between two stations. A conversation could and usually did contain more than one message.

† A message was considered to be a communication serving a single purpose. That purpose could be critical or noncritical to the effective operation of the battalion. A critical message was a communication serving a command, weapons control, intelligence, or administrative-logistics function.

(8) In INDIGO I, 58 percent of the messages sent on the Tk Gp ↔ Tk Co type-links were command messages, 4 percent were weapons control, and 38 percent were intelligence messages. However, the number of intelligence messages used in determining these percentages represented only the intelligence information flowing up the chain of command. If these are adjusted by assuming that each intelligence message sent from the division to a tank group headquarters resulted in a message being sent to each company assigned to that group, then these (88) additional messages would change the above percentages to 43 percent command, 3 percent weapons control, and 54 percent intelligence.

The intelligence figures for the field exercises represent both the upward and downward flow of intelligence. An average of 31 percent of the messages of classes 1, 2, and 3 sent during the three exercises were command messages, 6 percent were weapons control, and 63 percent were intelligence messages. The magnitude of these figures is similar to that of the hypothetical percentages mentioned in the preceding paragraph.

(9) In the first exercise the least active (in terms of conversations carried) Bn ↔ Tk Co link differed by a factor of 2 from the most active Bn ↔ Tk Co link; this factor was again 2 in the second exercise and was 1.4 in the third exercise.

**COMMUNICATIONS DATA FOR TANK BATTALIONS:
FT STEWART, GA.**

INTRODUCTION

PROBLEM

This paper summarizes the armor battalion command-net communications traffic recorded during three exercises held at Ft Stewart, Ga., in the fall of 1959. The first exercise involved only the command elements of the tested battalion; the second and third exercises involved a full friendly battalion and an aggressor company—other forces were simulated by the task force control unit. An effort has been made to include sufficient background information to facilitate comparing the results of these exercises with the communications data for similar links in the INDIGO war games. Table 1 shows the scope of the three maneuvers. Analyses of traffic count, linkage, range, and message function were made for comparison with the INDIGO communication results; mobility was not considered here.

TABLE 1
EXERCISES STUDIED

Unit	Type of exercise	Dates	Duration, hr	Approximate hours of recorded data
3d Med Tk Bn	CPX	14–15 Sep 59	22.5 (141725–151600)	15
4th Med Tk Bn	FTX	20–22 Oct 59	50.5 (201630–221800 ^a)	36.5
3d Med Tk Bn	FTX	28–31 Oct 59	49 (281822–311000)	35.5

^aThis exercise actually lasted from 19 to 23 Oct, but data are available only for the hours shown.

SOURCES OF DATA

The principal source of data for this analysis was three sets of tape recordings of the battalion command nets of three 90-mm armor battalions of an armored division.

Additional sources of information included photographs taken of the intelligence and operations overlays at intervals throughout the exercises, the operations orders for the maneuvers, the signal operating instructions, and other material received from Ft Stewart.

A series* of Army Map Service (AMS) topographic sheets (1:50,000) proved helpful in interpreting the position data and in determining the communications ranges between the units.

*4647 IV Glennville, Ga.; 4647 I Hinesville, Ga.; 4648 III Claxton, Ga.; 4648 II Pembroke, Ga.; 4748 III Meldrim, Ga.; 4747 IV Limerick, Ga.

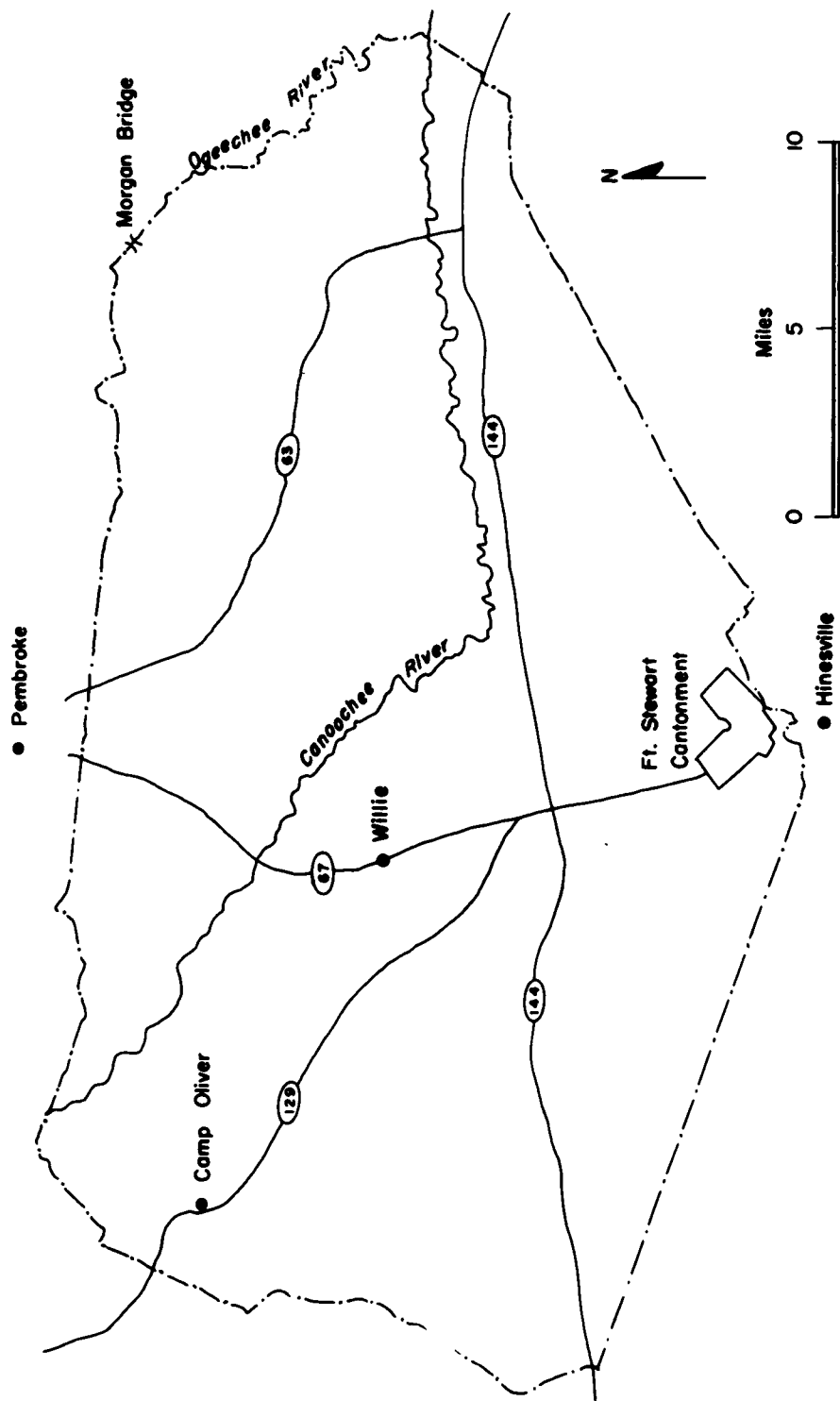


Fig. 1—Base Map of Ft. Stewart, Ga.

GEOGRAPHY OF FT STEWART

This section covers the general characteristics of the terrain and environment common to the three exercises; information unique to a particular exercise is included in the discussion of that exercise. A more detailed description of the Ft Stewart reservation may be found in App B.

Location and Size

Ft Stewart is located about 40 miles southwest of Savannah, Ga., and about 40 miles inland from the Atlantic Ocean; it lies between the southeast-flowing Ogeechee and Altamaha rivers (Fig. 1).

Topography

The area of Ft Stewart lies in the Atlantic Coastal Plain physiographic province and has the characteristic slightly rolling to level terrain. The elevations on the reservation range from about 4 ft above sea level in the eastern part to a little over 180 ft on the western border of the reservation.

Although most of the area is gently sloping, a series of 30- to 40-ft escarpments rise from the Canoochee River.

Culture

The road net of the reservation consists largely of improved and unimproved light-duty roads. Georgia State Highways 144, 67, and 63 cross the reservation. A considerable network of dismantled logging railroad covers the area. Because of the extremely poor conditions for off-road travel most of the movement during the exercises was confined to the road system.

Three airfields are on the reservation: Liberty Field near the Ft Stewart cantonment, an airstrip at Camp Oliver, and a second airstrip 4 km southwest of Camp Oliver.

Trafficability

Most of the reservation is impassable for off-road traffic at least half the year. Belts of terrain that are impassable the year round parallel the streams. Areas considered passable throughout the year are found only in the far western part of the reservation; the second and third exercises were conducted in this section.

Drainage

A large part, perhaps 35 percent, of the area of the reservation is classified as swamp.

Vegetation

Roughly 75 percent of the Ft Stewart reservation is forested; clearings are confined chiefly to the garrison areas, the several firing ranges, and the airstrips.

Climate

The climate of the area is considered semitropical; it receives an average of 50 in. of precipitation a year.

METHODOLOGY

METHODOLOGY OF ANALYSIS

This section covers the methods used in reducing the recorded communications to an analyzable form, the assumptions made in formulating the methodology, and the definitions and conventions followed during the data reduction and analysis.

Appendix C is a check list of information to be gathered in the field which would be useful in the preparation of a report covering the communications aspects of future exercises for comparison with gaming results.

Preliminary Analysis

The analysis of the data from the Ft Stewart exercises began with the transcription of the tape recordings and simultaneous classification of the message content as to function. The transcription process was later modified to include a breakdown of the conversations by type-links, a count of the frequency with which messages of each function class occurred, and the determination of the number of messages composing each conversation.

The ranges between units were determined from photographs taken of the operations and from intelligence overlays at various stages in the maneuvers.

Scope of Presentation

In addition to the communication data from the exercises, details of the terrain utilized, the size and branches of the units involved (both friendly and aggressor), the hours of activity, the over-all length of the exercise, and an indication of the weather conditions influencing the operations have been summarized and included. These details are provided to facilitate comparison of these communications data with the results of operations or simulations carried out under similar conditions.

This paper is concerned only with the hours for which recorded traffic was available. Within these hours of monitoring there were periods of heavy static and intervals when the recording equipment was shut off for tape changes, etc. During these periods some messages were very likely sent; however, the number of these unrecorded messages is considered negligible.

No measure of the length of the individual conversations (e.g., number of words, duration of transmission, etc.) has been made here other than the messages per conversation.

Only the maximum ranges for the Bn HQ ↔ Tk Co type-link were considered, and the resulting figures appear reasonably accurate (within ±3 km). The data available were insufficient to yield a complete Bn HQ ↔ Tk Co range distribution. Since the platoons of the armor companies do not have stations on the battalion command net they were not considered in the traffic count. The data were not sufficient for a determination of mobility for any of the exercises.

Remarks

The number of hours of recorded data was approximated from the time checks on each of the tapes, and the maximum recording time per tape reel. It was assumed that the dead time appearing on the tapes was normal and that the recording process was continuous unless the people monitoring the exercise mentioned a cessation of recording activity. (Remarks from the ORO personnel monitoring the exercise were included on the tapes at irregular intervals; these remarks were brief and usually consisted of the date and the hour of the interruption.)

The time checks were automatically spaced at intervals of approximately $\frac{1}{2}$ hr on the first exercise, since the recording was done on small reels having $\frac{1}{2}$ -hr capacity; the second and third exercises were recorded on larger reels (3-hr 12-min capacity), and the time checks were irregularly spaced, resulting in intervals of approximately 1 hr.

The references to nuclear activity were based on the communications requesting, acknowledging, or reporting nuclear bursts.

In the instances in which a conversation from Gp HQ ↔ Bn HQ caused the Bn HQ to issue orders to one or more companies, the Gp ↔ Bn conversation was counted as one and each of the resulting Bn ↔ Co conversations was counted separately.

For determining ranges it was further assumed that the Bn HQ stations were at the position denoted by the Bn HQ symbol on the overlays and that the company stations on the battalion command net were also at the position denoted by their symbols.

It was assumed that all the tank companies, as well as the Bn HQ and Gp HQ, were alive for the duration of each maneuver.

Definitions

In transcribing the tape recordings certain conventions were adopted:

Time Period. The interval between successive time checks on the recording tapes was called a "time period." (These checks usually were not equally spaced on the recordings of the second two maneuvers.)

Class. The class to which the message is assigned denotes its function or lack of function:

- 1 command
- 2 weapons control
- 3 intelligence (3S + 3I)
- 3S situation report (no enemy information)
- 3I information about the enemy
- 4 administrative, logistics

NC messages that were intelligible to the transcriber of the tape recordings and yet were classed as noncritical (nonessential) to the operation of the battalion being monitored. These communications were largely communications checks.

Obs obscured (not intelligible to the transcriber)

Rp Rq repeat request (in this investigation the original message was counted as one message whereas the request for repetition and the repetition were counted as a second message)

UN messages consisting solely of an exchange of call signs or of unanswered call signs with no accompanying message content

Station. A station is considered one of the participants in a conversation.

Node. For purposes of traffic count and range determination, the term "node" refers to the group of stations at one location, e.g., the Bn HQ node—made up of the Bn HQ stations.

Message. A communication serving a single purpose, e.g., command, weapons control, etc. If repetition of a message is requested the original message is counted as one message; the request for repetition and the repetition itself are counted as a second message.

Conversation. A conversation is a continuous verbal exchange between two stations; the conversation may be composed of several messages. A conversation between more than two stations is broken down into two-station conversations and then counted.

Critical. A critical message is one whose function has been classified as class 1, 2, 3, 3S, 3I, or 4.

Noncritical. A message unnecessary to the combat effectiveness of the unit, i.e., any messages included in classes NC, Obs, and Rp Rq.

Obscured. A message was classified as obscured if the message was unintelligible to the transcriber because of interruption by other stations, heavy static, etc.

Gp ↔ Gp (internal). The communication link between two stations of the combat group headquarters commanding the tested battalion.

Bn ↔ Bn (internal). The communication link between two stations of the tested battalion headquarters.

Co ↔ Co. The communication link between two company headquarters stations. (The stations may be in the same company headquarters but usually were in different ones.)

Gp ↔ Bn. The communication link between a group headquarters station and battalion headquarters station.

Bn ↔ Co. The communication link between a battalion headquarters station and a company headquarters station.

Gp ↔ Co. The communication link between a group station and a company headquarters station.

Bn ↔ Unknown. The communication link between a battalion headquarters station and an unidentified station.

Co ↔ Unknown. The communication link between a company headquarters station and an unidentified station.

Unknown ↔ Unknown. The communication link between two unidentified stations.

Range. The distance between the two nodes of a link during the time the link is in use.

Link. The communication connection between two nodes, two stations, or a node and a station.

Type-Link. The links of the battalion command net were classified by the echelons of the nodes that determined these links; thus we have the Gp ↔ Bn type-link, the Bn ↔ Co type-link, etc.

Techniques

In the transcription process each recorded conversation was classified as to the echelons of the nodes participating in the conversation, the classes of the component messages, and the number of messages per conversation.

The stations comprising the headquarters of the 3d and 4th Med Tk Bn were considered as being one node for determining the Bn ↔ Co range distributions and for determining the number of links.

In the first maneuver the range distributions for the Bn ↔ Tk Co link were determined for three distinct phases: the preassembly area stage, in which the range data were obtained exclusively from the transcription sheets and from the coordinates of the check points; an assembly stage, during which the battalion stayed within the assembly area; and a postassembly stage, in which the range data were determined from photographs of the maneuver overlays. The ranges for the second and third exercises were obtained from the photographs of the overlays.

Several of the tables in this paper show percentages with three significant figures; the additional figure was included for consistency within the table. It is not intended to imply, for instance, that the number of Gp ↔ Bn conversations sent during a given exercise is known to within one conversation. Accuracy, as opposed to precision, is probably about 10 percent.

In this paper the symbol Gp ↔ Gp (internal) denotes the conversations held between two stations of the combat group to which the tested battalion was assumed to be assigned. The Bn ↔ Bn (internal) conversations are those which were held between two stations of the tested battalion's headquarters. These cannot be compared with the results of the INDIGO operation, since this type of communication was handled orally at the game table and was never tabulated.

3D MED TK BN COMMAND NET: CPX 14-15 SEP 59

INTRODUCTION

Operation

The command elements of the 3d Med Tk Bn (Patton) of the 32d Armd Regt were tested in a CPX on 14-15 Sep 59 at Ft Stewart, Ga. The enemy in this exercise was simulated by the control-umpire unit, which also functioned as the combat group headquarters for the battalion being tested. The exercise lasted from 141700 Sep until approximately 151600 Sep, a period of 23 hr. By monitoring the battalion command net, approximately 15 hr of recorded data were obtained.

In this exercise the 3d Med Tk Bn formed a tank-heavy battalion task force of four teams, each having a tank company as its nucleus (see App A for combat organization). The problem situation assumed that the aggressor forces were conducting limited objective operations along the eastern boundary (the Ogeechee River) of Ft Stewart.

The CPX was divided into three phases: the first was a tactical march of about 61 km; the second was a counterattack known as Plan Smasher; the third was westward withdrawal parallel to Highway 144.

During the first phase the task force marched, in about 4.5 hr, from Camp Oliver in the northwest corner of the reservation to Blocking Position

TABLE 2
DISTANCE AND TRAVEL TIME BETWEEN CHECK POINTS^a

Check points	Distance, km	Average travel time, hr	Estimated average travel rate	
			Mph	Km/hr
Initial point to check point 1	16.5	1.0	10	16
Check point 1 to 2	16.0	1.2	9	14
Check point 2 to 3	10.4	0.9	8	12
Check point 3 to 4	9.6	0.7	9	14
Check point 4 to release point	8.0	0.8	6	10
Initial point to release point	60.5	4.6		

^aThese check points were located on the route of march from Camp Oliver to Position Cook.

Cook in the southeastern part of Ft Stewart. The first segment of the route (10.5 miles) carried the task force southward along Ft Stewart roads 1 and 5 to Georgia State Highway 144; the second segment proceeded roughly eastward paralleling Highway 144 for another 27.5 miles to Position Cook. Table 2 indicates the distances between the check points along the route and the average time that was taken to cover these distances; from this information an estimate was made of the column's average speed between each pair of check points. Darkness (end, evening nautical twilight) at 1957 found the head of the column at ChP 3 and the last march unit between ChP 1 and ChP 2.

The last unit cleared the release point in Position Cook at approximately 2235 on 14 Sep; the release point was about 17 km northeast of the Ft Stewart cantonment. Position Cook was a parallelogram-shaped area of about 12 sq km straddling the Canoochee River. The four teams were assigned areas in the corners of the parallelogram that were connected by improved light-duty roads and a bridge over the Canoochee.

During the late evening and early morning hours the group control station sent simulated intelligence reports of enemy patrol action and movement to the battalion. These reports indicated enemy forces to the northeast and to the southeast of Position Cook, the key point being Morgan Bridge over the Ogeechee River. Reports were also sent to the battalion on the activity of the other two combat groups, which were simulated to be operating in sectors on either side of their own area.

Between 0615 and 0630 on 15 Sep the units moved out of Position Cook under counterattack Plan Smasher, the second phase of the mission. The plan was to contain the penetration, which became Objective Peach, of the 207th and 233d enemy infantry regiments in the northeast corner of the reservation. The plan called for two axes of attack running about 7 km northward from Position Cook to Objective Peach. Team A moved along the western axis; teams B, C, and D used the eastern axis for about 5 km. From this point Team C moved northeastward to a blocking position near Morgan Bridge while Teams B and D turned northwestward toward the eastern flank of Objective Peach.

At about 1240 the combat groups were ordered to withdraw westward in the face of enemy offensive action to the north and east of Cook to successive positions along Highway 144, with the mission of maximum delay in the sector east of Phase Line Virginia. This withdrawal constituted the third and final phase of the exercise, ending at 1600.

Both the friendly and enemy forces were assumed to have nuclear capability and both simulated the use of these weapons, chiefly in low airbursts. The control-umpire unit sent messages to the battalion concerning the nuclear activity in the taskforce sectors on either side of the battalion area. From the recorded communications the use of nuclear weapons seems to have been confined to the period between 0530 and 1450 on 15 Sep.

Friendly tactical aircraft (simulated) provided intelligence and some air support. Limited action by the enemy tactical aircraft was indicated on the recordings, but friendly units were said to have air superiority.

The aggressor forces mentioned on the tape recordings and on the intelligence overlays included:

1. 233d Rifle Regt
2. 207th Rifle Regt

3. 47th Armd Regt

4. A battalion of the 343d Mecz Regt

The attack phase of the exercise for the tested battalion was carried out in a roughly rectangular area 15 by 9 km; the withdrawal corridor was roughly 17 km long and 5 km wide.

Weather and Visibility Conditions

As shown in Table 3, the exercise took place during a period of warm rainy weather. A heavy rain on 13 Sep was responsible for the muddy condition of the unsurfaced roads and tank trails.

Sunrise was at 0608 and sunset at 1830 on 14-15 Sep.

TABLE 3
PRECIPITATION AND TEMPERATURE DATA,
6-15 SEP 59

Date	Total precipitation ^a	Temperature, °F	
		Maximum	Minimum
6	0.32	87	72
7	T ^b	87	72
8	0.74	90	70
9	0.08	88	70
10	0.02	88	70
11	—	88	68
12	0.47	81	71
13	1.26	75	66
14	0.03	73	65
15	0.06	77	63

^aTotal precipitation, in inches, measured during the 24-hr period ending at 1900 on the day indicated.

^bT, trace, an amount too small to measure.

DATA

In transcribing the recorded communication traffic each continuous verbal exchange between the same two stations was counted as a conversation. Within a conversation each order and its acknowledgment, each transmission of intelligence and its response, etc., were counted as a single message. Using this system each conversation could, and often did, have several component messages. Each message was then classified according to function, i.e., command, weapons control, intelligence, etc.

In the following sections the traffic-count figures will be in terms of conversations; the discussion of the message function results will be in terms of messages.

The data used in the following analysis were recorded on reels of magnetic tape that had a running time of about 30 min. In most cases the recordings were continuous so that the data were automatically recorded by 30-min intervals.

Traffic Count

Table 4 is a tabulation of approximately 15 hr of communications traffic, recorded during a maneuver lasting about 23 hr. (The major portion of the 8 hr of dead time occurred while the unit was shut down during the late evening and early morning hours in Position Cook.) The first column of Table 4 shows the recorded conversations in which both the originator and the addressee were known, those in which only one of the participants (originator or addressee) was known, and those in which neither participant could be identified. The conversations of the last two categories were distributed proportionately among the several types of known-originator ↔ known-addressee conversations; the results of this distribution are shown in the right-hand column of Table 4. All subsequent references to the conversation distribution of this maneuver will refer to the adjusted distribution shown in the right side of Table 4. The notation Gp ↔ Gp (internal) indicates the link connecting two stations of the combat group to which the tested battalion was assigned—these are internal communications rather than lateral communications. The notation Bn ↔ Bn (internal) refers to the links joining stations of the tested battalion's headquarters.

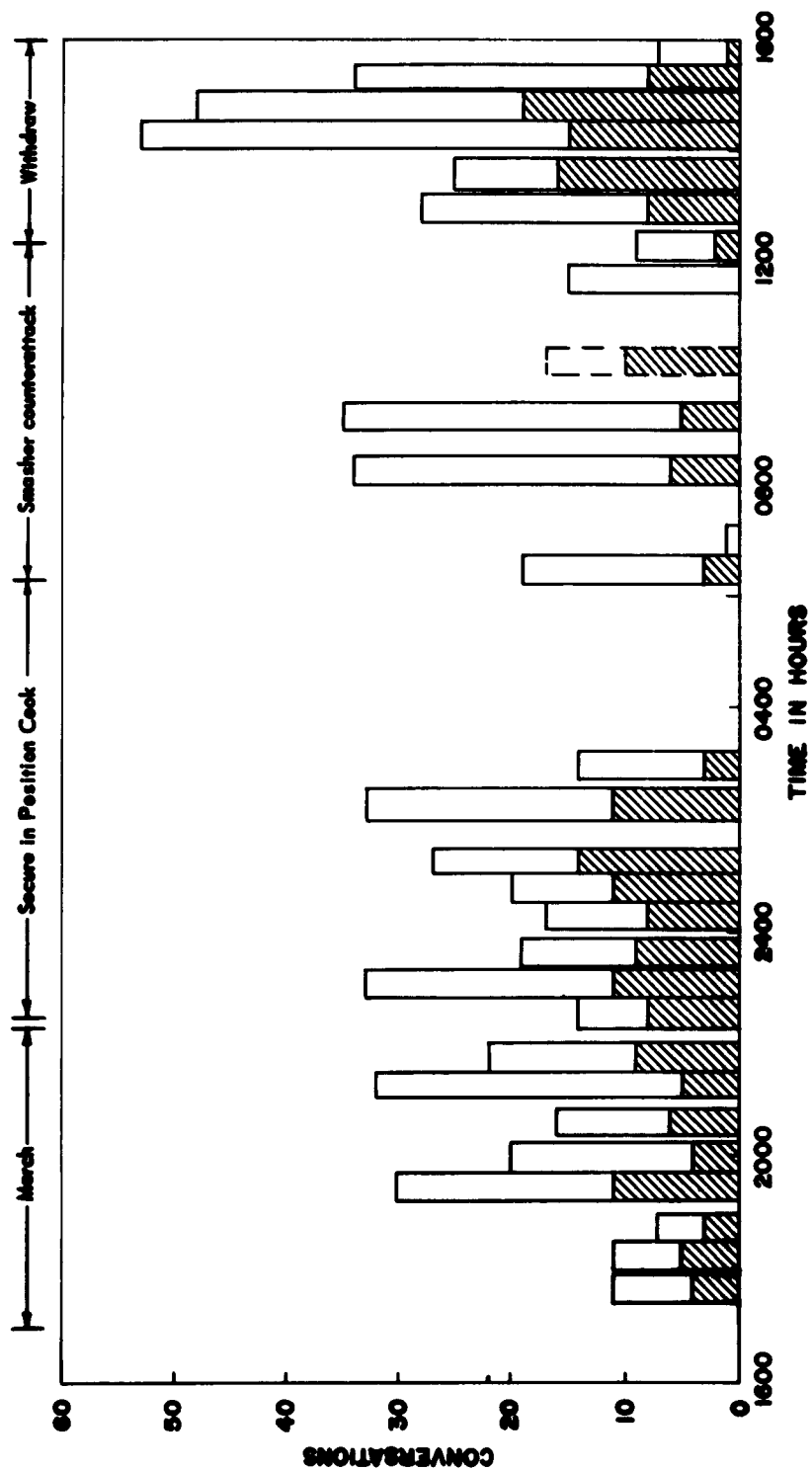
TABLE 4
BATTALION COMMAND NET: CONVERSATION DISTRIBUTION BY
TYPE-LINK, CPX 14-15 SEP 59

Link	Unadjusted distribution		Adjusted distribution	
	Conversations	Percent of total	Conversations	Percent of total
Gp ↔ Gp (internal)	5	0.8	5	0.8
Bn ↔ Bn (internal)	144	22.1	167	25.6
Co ↔ Co	42	6.5	48	7.4
Gp ↔ Bn	162	24.8	183	28.1
Bn ↔ Co	198	30.4	244	37.5
Gp ↔ Co	3	0.5	4	0.6
Bn ↔ unidentified	48	7.4		
Co ↔ unidentified	14	2.0		
Unidentified ↔ unidentified	35	5.4		
Total	651	100	651	100

Figure 2 shows the traffic count, plotted by intervals of about 30 min, for all the links that were monitored; the shaded area represents the number of recorded conversations between a battalion headquarters station and a company station. (The Bn HQ ↔ Tk Co type-link is of primary interest to Study 42.6 and has been emphasized in this section and in subsequent sections of the analysis.) The periods occupied by the major phases of the maneuver are shown at the top of Fig. 2.

The interval from 0645 to 0715 was a period of extreme interference; the one recorded conversation occurred during a brief break in the heavy background noise.

Between 0930 and 1125, 17 conversations took place during a period of about 30 min; 10 of these involved a battalion headquarters station and a



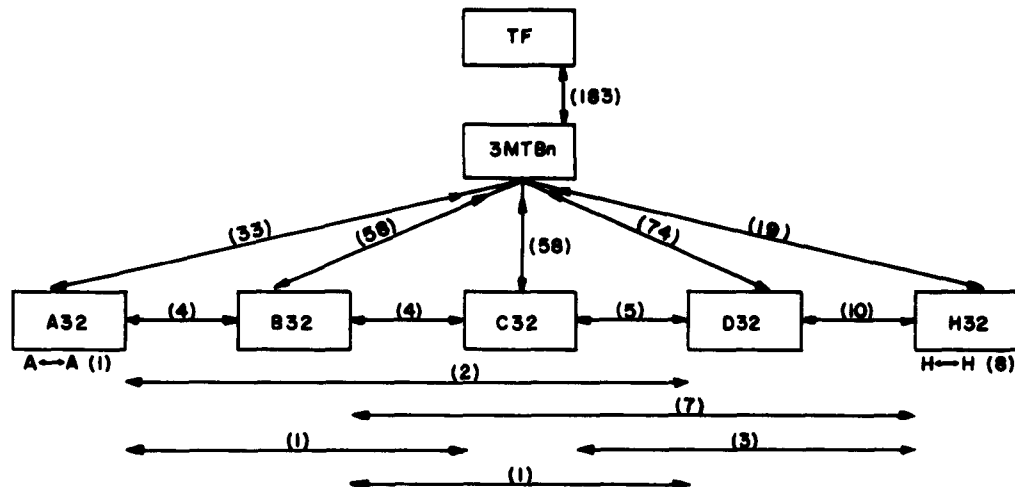


Fig. 3—Conversation Distribution by Link, CPX 14-15 Sep 59

company station. However, there were no time checks to indicate the limits of this period, which has been represented by dotted lines.

The 0200 beginning time of the period ending at 0240 is also estimated.

The busy hour occurs from 1405 to 1505, during the withdrawal phase of the maneuver.

Figure 3 shows the traffic count for each link indicated in the recordings with the exception of the battalion ↔ battalion (internal) and group ↔ company links that are shown in Table 4.

The 183 group ↔ battalion conversations represent 28.1 percent of the total traffic for the maneuver; the 244 battalion ↔ company conversations form 37.5 percent.

In Fig. 3 the combat team with the lowest traffic count, A32, differed by a factor of approximately 2 from the most active combat team, D32. The least active company link, H32, differed by a factor of almost 4 from D32.

Message Function

The preceding discussion has been in terms of conversations; however, the objectives of ORO Study 42.6 require an analysis of the critical messages—communications performing only one function, one that is essential to the combat effectiveness of the unit. The following discussion is in terms of messages as previously defined in the section "Methodology," particularly those messages necessary to the combat effectiveness of a field unit.

Figure 4 shows the distribution of messages during the September CPX. The dotted lines again represent the estimated boundaries of 30-min time periods for which one or both of the limiting time checks were omitted on the recording. The shaded areas indicate the number of critical messages sent during a given time period.

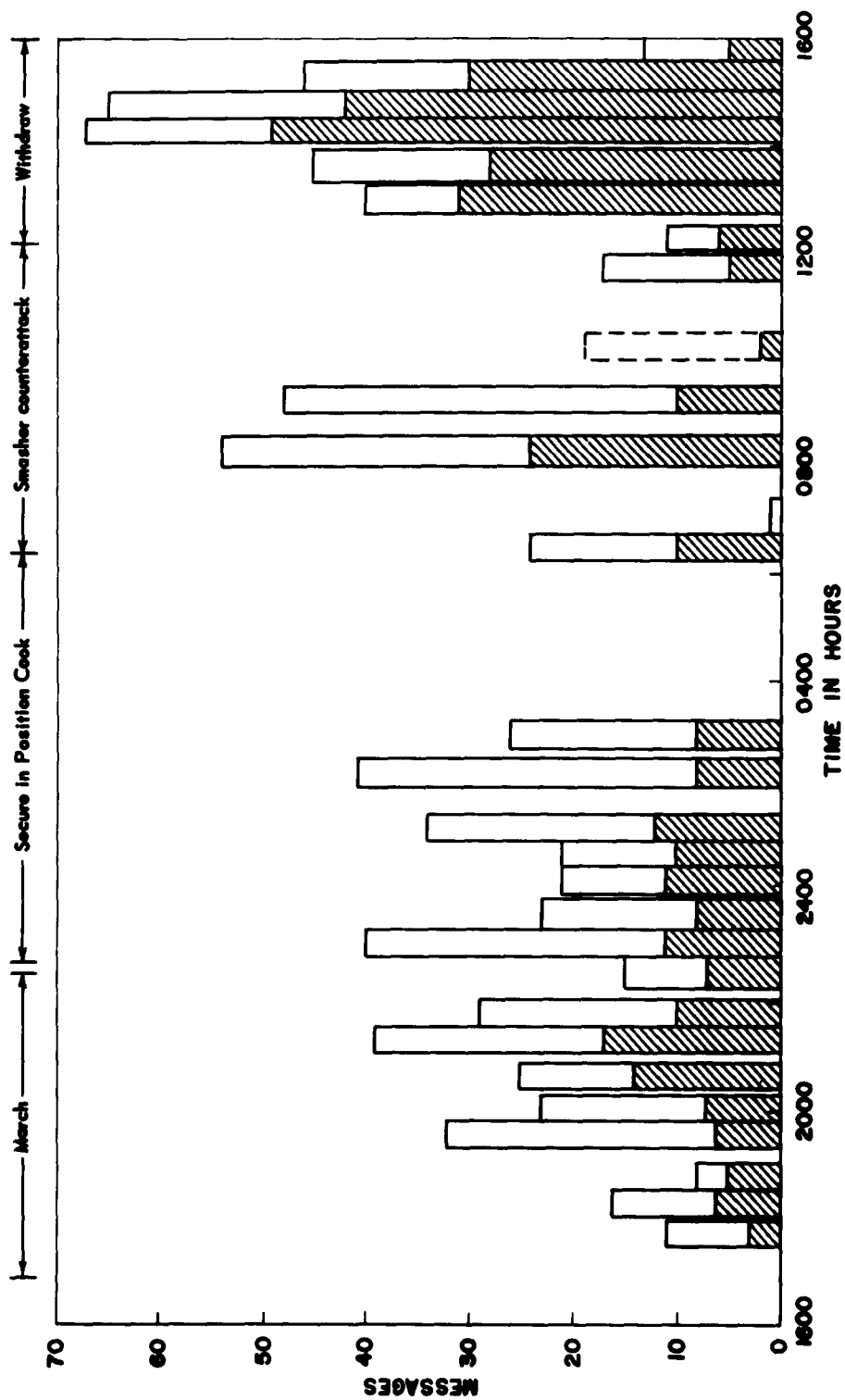




Fig. 4— Distribution of Messages, CPX 14-15 Sep 59

 Critical messages
 Messages that served noncritical functions

The busy hour (1405 to 1505) averaged 69 percent critical messages; 45.5 percent of all the messages sent during the maneuver were classed as critical.

Figure 5 shows the distribution of the critical messages shown in Fig. 4. The messages sent during each time period are broken down into five classes according to function (the definitions of the six classes of critical messages previously given in the section on "Methodology" are repeated here for the reader's convenience):

- 1 command messages
- 2 weapons and control messages
- 3 intelligence messages
- 3I intelligence (information about the enemy) messages
- 3S situation reports (no enemy information)
- 4 administrative, logistics

The messages that could be classified as intelligence messages (class 3) were broken down a step further into a class of routine messages (3S)—largely situation reports—that contained no information about the enemy, and a second class (3I) that were messages actually containing information about the enemy. Of the 845 recorded messages, 96 (11 percent) contained information about the enemy (class 3I). Situation reports and friendly position locations numbered 181 (21 percent). The combination of class 3I and class 3S (277 messages) formed 33 percent of the messages sent during the maneuver.

Table 5 shows the breakdown of the noncritical as well as the critical recorded messages. Fifty-four percent of the messages were found to be noncritical (i.e., messages of classes NC, UN, Rp Rq, and Obs as defined in the section "Methodology").

Table 5 shows that 29 percent of the recorded messages were of the noncritical class; most of these were communications checks. The number of UN, Rp Rq, and Obs entries indicates that a large number of the messages did not get through to the addressee on the first try.

TABLE 5
MESSAGE DISTRIBUTION BY CLASS,
CPX 14-15 SEP 59

Class	Messages	Percent of total
Command (1)	78	9.2
Weapons (2)	28	3.3
Intelligence (3)	96	11.4
Situation report (3S)	181	21.4
Administrative, logistics (4)	2	0.2
Noncritical (NC)	244	29.0
Unanswered calls (UN)	146	17.3
Repeat request (Rp Rq)	34	4.0
Obscured (Obs)	36	4.3
Total	845	100

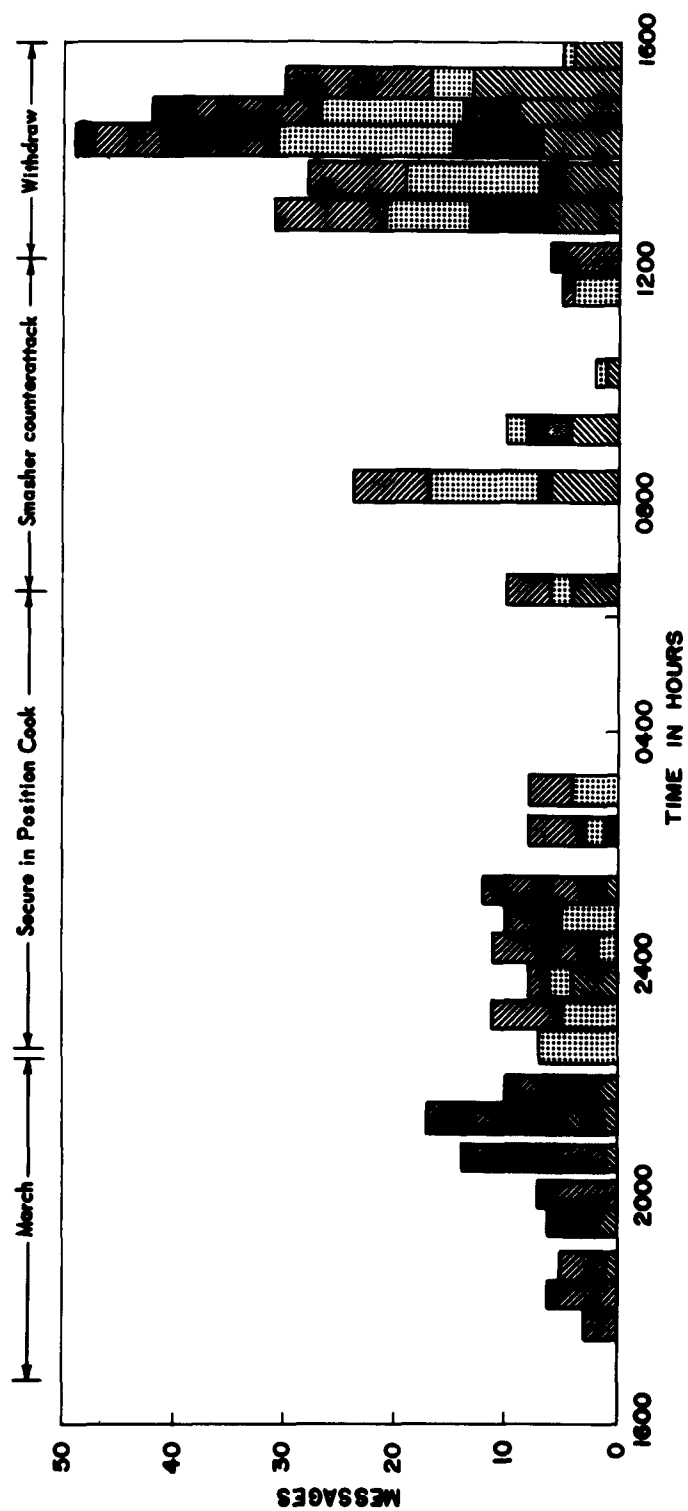


Fig. 5—Distribution of Critical Messages, CPX 14-15 Sep 59

- Class 1, Command
- Class 2, Weapons control
- Class 3I, Intelligence (information about the enemy)
- Class 3S, Situation report
- Class 4, Administrative, logistics

Messages per Conversation

The earlier discussions on the relation between conversations and messages indicated that the message is a communication serving one function whereas the conversation is a continuous verbal exchange that may contain several component messages. Table 6 shows the number of conversations composed of x messages.

TABLE 6
MESSAGES PER CONVERSATION,
CPX 14-15 SEP 59

x	Conversations having x component messages	Percent
0 ^a	182	27.9
1	338	52.1
2	88	13.5
3	25	3.8
4	14	2.1
5	1	0.2
6	1	0.2
7	1	0.2
Total	651	100

^aThe 182 conversations listed as having no component messages were those consisting solely of an exchange of call signs, and others in which a message was exchanged but was unintelligible on the tape recording.

Conversations having no component messages are those consisting of an exchange of call signs, those in which the message content was unintelligible, and those in which a call was unanswered. There were 182 cases with no recorded evidence that the message content got through on the first try. In many cases the call was repeated successfully; in others the messages were very likely received by the addressee but were not recorded, e.g., the obscured messages.

Table 6 shows that 52.1 percent of the recorded conversations (339) were communications serving only one function.

Links

Table 7 shows the activity of the links involved in the maneuver. In this table it is assumed that there were four battalion HQ ↔ tank company links, each of which was in existence for the whole maneuver, and that the record covers a period of 15 hr.

The results for the battalion command net in the exercise show that there was an average of 1.3 messages/conversation and 0.6 critical message/conversation.

The battalion command-net message data show 56.3 messages/hr over the battalion command net; of these, 25.6 were critical.

TABLE 7
CONVERSATIONS PER LINK HOUR, CPX 14-15 SEP 59

Link	Conversations	Link hours	Conversations per link hour
Gp ↔ Bn	182	15	12.2
Bn ↔ Tk Co	223	60	3.7
Bn ↔ Co ^a	242	75	3.2
Bn ↔ A32	33	15	2.2
Bn ↔ B32	58	15	3.8
Bn ↔ C32	58	15	3.8
Bn ↔ D32	74	15	4.9
Bn ↔ H21	19	15	1.2

^aIncludes the Bn ↔ H&S Co conversations.

The conversation data show 43.4 conversations/hr. The Bn HQ ↔ Tk Co link carried an average of 19.5 messages/hr; the four battalion HQ ↔ tank company links averaged 4.9 messages/hr/link.

Ranges

The ranges for the Bn ↔ Tk Co link were determined by using the check points and travel time for the period of marching, an overlay from Position Cook for the time spent by the battalion in that area, and slides taken of the overlays of the maneuvers for the counterattack phase. The data for the withdrawal phase were not sufficient to give distances of comparable accuracy; however, there were no indications of battalion headquarters ↔ company distances greater than 10 km; 90 percent of the ranges were 8 km or less.

4TH MED TK BN COMMAND NET: FTX 20-22 OCT 59

INTRODUCTION

Operation

The 4th Med Tk Bn (Patton) of the 68th Armd Regt was tested in an FTX on 19-23 Oct 59 at Ft Stewart, Ga. About 36.5 hr of tape recordings of the battalion command-net traffic are available for the 50.5-hr period from 1630 on 20 Oct to 1800 on 22 Oct. In this exercise the tested battalion again formed a tank-heavy battalion task force of four teams each having a tank company as its nucleus (see App A for Combat Organization).

19 Oct 59. TF Spur, the 4th Med Tk Bn and attached units, moved southward in a column of teams from Camp Oliver at about 1500. The march continued southward along the western boundary of the reservation for about 17 km to fixing positions on either side of Highway 144; these positions were about 7 km from the western limits of the reservation.

The mission of the task force was to deny enemy access to critical terrain in this sector, to canalize the enemy into Killing Ground (KG) Knockout,* and to be prepared to attack, defend, counterattack, or perform delaying missions on order.

20 Oct 59. On 20 Oct elements of an aggressor mechanized division were reported along a northeast-southwest line through Hinesville (see Fig. 1); during the early morning hours the aggressor sent out small patrols to probe the TF Spur sector.

The mission of TF Spur was to execute a fixing mission in its combat command sector, initially defending along the forward edge of the battle area (FEBA) and finally fixing the enemy in KG Knockout. The TF was also to deny critical terrain in the sector to the enemy, to be prepared to support or reinforce the counterattack of the division striking force on order, and to prepare plans to conduct delay in the sector on order. During this phase of the exercise the priority of supporting fires was initially to TF Spur; on-call nuclear missions were available for targets of opportunity.

The aggressor threat was stopped temporarily at about 1145 by a counter-attack and an effort was made to canalize the enemy into the killing ground. At

*KG Knockout was an oval area of about 4 sq km the southern limit of which crossed Highway 144 about 7 km from the western border of the reservation. The positions of Companies B and C were located 3 to 4 km to the east of the KG, and A Co and D Co were located west of the KG.

1615 the division employed a preplanned atomic strike on the enemy penetration; a simulated division striking force attacked the aggressor at 1630. At 1900 the TF was told to reorganize the original term positions and to establish security for night occupation; they were to be prepared to execute a delaying mission at any time within the 8-hr period following 202000 Oct.

21 Oct 59. The operations continued in the same area on 21 Oct. Early in the morning Co D prepared to occupy its alternate position about 2 km south of its initial position. Co A moved eastward to a position between the locations of Cos B and C.

Friendly nuclear low airbursts (10 KT) were fired at about 0800 and 1645. At about 1000 the friendly units were subjected to a gas attack.

From 1100 until about 1600, Cos A and B were involved in heavy action. During the period 1645-1755, the companies secured their positions.

22 Oct 59. The operations consisted of organizing and occupying initial delaying positions and then proceeding with a westward delaying action through successive delay positions. The operation in this exercise was confined to the southwest quarter of the reservation.

The aggressor had massed along a northeast-southwest line across the two TF areas. In the TF Spur area Cos D and C occupied positions along delay position Apple; Co A held in the east, and Co B occupied an intermediate position. Co A fell back through Co C, leaving Co B the easternmost company. This delaying action kept the aggressor east of Camp Oliver until forces for a counterattack could be assembled. The counterattack occurred on 23 Oct.

Weather and Visibility Conditions

Table 8 shows the temperature and precipitation conditions affecting the maneuver. The heavy rains on 21 and 22 Oct had considerable adverse effect on the trafficability of the terrain; most of the area is regarded as passable in the dry season but impassable during the wet season.

TABLE 8
PRECIPITATION AND TEMPERATURE DATA
14-23 OCT 59

Date	Total precipitation ^a	Temperature, °F	
		Maximum	Minimum
14	0.46	83	70
15	0.04	72	61
16	0.20	61	55
17	0.10	73	60
18	—	75	64
19	—	73	55
20	—	82	60
21	0.93	75	65
22	0.65	70	63
23	0.40	78	64

^aTotal precipitation, in inches, measured during the 24-hr period ending at 1900 on the day indicated.

DATA

In the following discussion the same definitions of conversation, messages, etc., will be used as in the previous section.

The time checks for this exercise and the one for 28-31 Oct were irregularly spaced so that the data have not been plotted by $\frac{1}{2}$ -hr intervals as in the 14-15 Sep maneuver.

Traffic Count

Table 9 shows the distribution of conversations throughout the maneuver on the basis of type-link activity. It indicates the number of conversations carried by each link and the percentage it represents of the total number of conversations recorded during the maneuver. In the breakdown of the data a count was made of the number of conversations in which one or both of the nodes of the type-link were unidentified. The unadjusted distribution shows these values; the adjusted distribution is the result of assigning these conversations of uncertain origin proportionately among the links whose nodes were both identified. Comparisons of conversation type-link activity in other parts of this paper will refer to the adjusted distribution.

TABLE 9
BATTALION COMMAND NET: CONVERSATION DISTRIBUTION BY
TYPE-LINK, FTX 20-22 OCT 59

Link	Unadjusted distribution		Adjusted distribution	
	Conversations	Percent of total	Conversations	Percent of total
Gp ↔ Gp (internal)	7	0.8	7	0.8
Bn ↔ Bn (internal)	117	13.6	139	16.2
Co ↔ Co	74	8.6	78	9.1
Gp ↔ Bn	5	0.6	6	0.7
Bn ↔ Co	508	59.1	629	73.2
Gp ↔ Co	—	—	—	—
Bn ↔ unidentified	114	13.4	—	—
Co ↔ unidentified	26	3.0	—	—
Unidentified ↔ unidentified	8	0.9	—	—
Total	859	100	859	100

The adjusted distribution shows that the battalion ↔ company link carried 629 conversations, 73.2 percent of the 859 total recorded conversations.

The conversations having at least one unidentified node numbered 148, 17.3 percent of the total number of conversations.

Figure 6 shows the distribution of the conversations as a function of time. Shading on the figure shows the number of Bn ↔ Co conversations taking place during the time represented by each bar. It will be noted that for the most part the length of time covered by each bar is about 1 hr, although several bars occupy shorter and longer periods of time. The busy hour for this

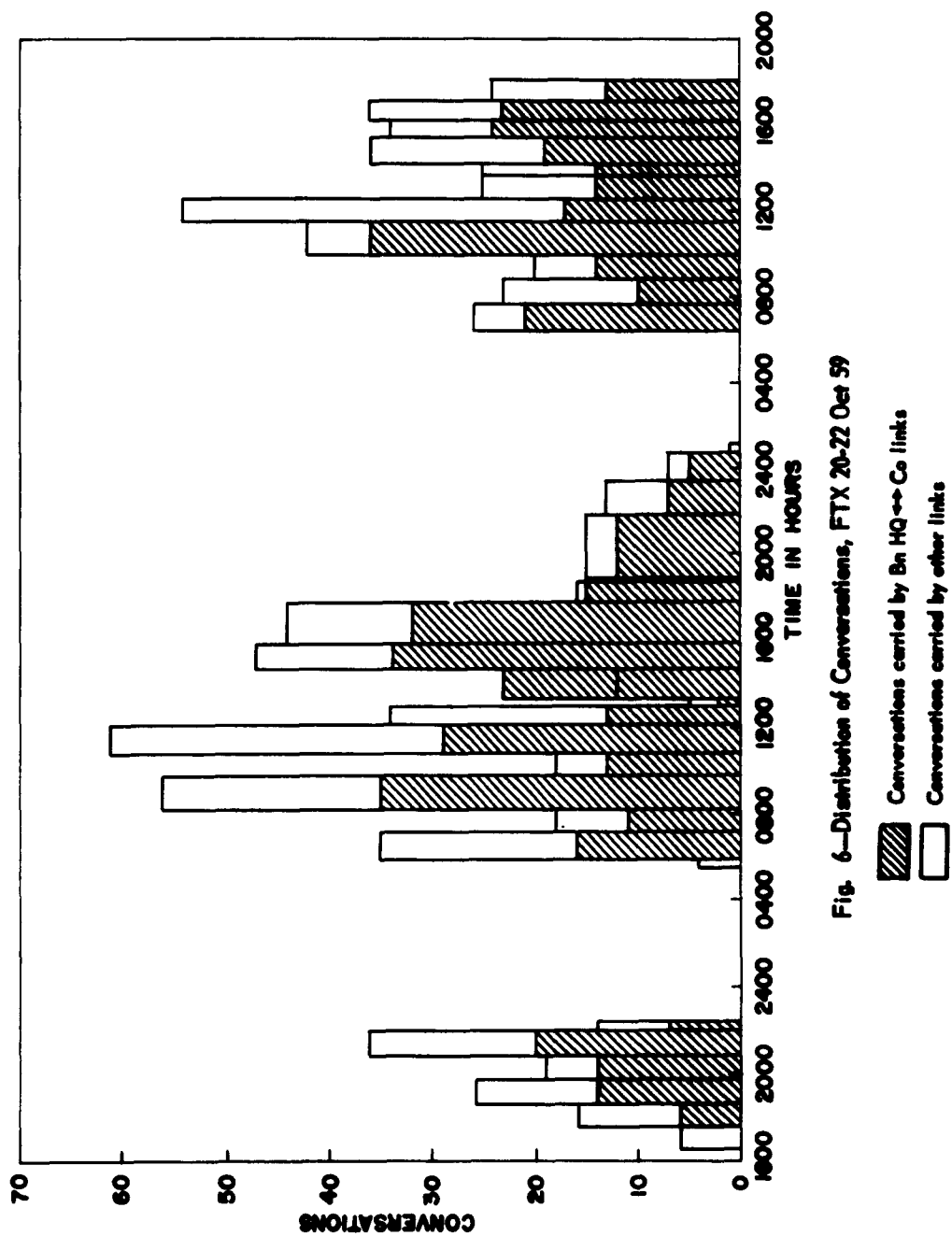


Fig. 6—Distribution of Conversations, FTX 20-22 Oct 59

exercise occurred during the 1050-1205 period on 21 Oct. During this period 61 conversations took place. Of these, 29 were Bn ↔ Co conversations. The breaks on the taped record longer than 5 min are confined to the early morning hours when the operation was shut down.

Figure 7 shows the conversation distribution for each of the Bn ↔ Co links as well as the Gp ↔ Bn and Co ↔ Co link activity. The Bn ↔ Co link carried the most conversations: 168 or 32.5 percent of the Bn ↔ Tk Co conversations. The least active Bn ↔ Tk Co link differed by a factor of approximately 2 from the most active link.

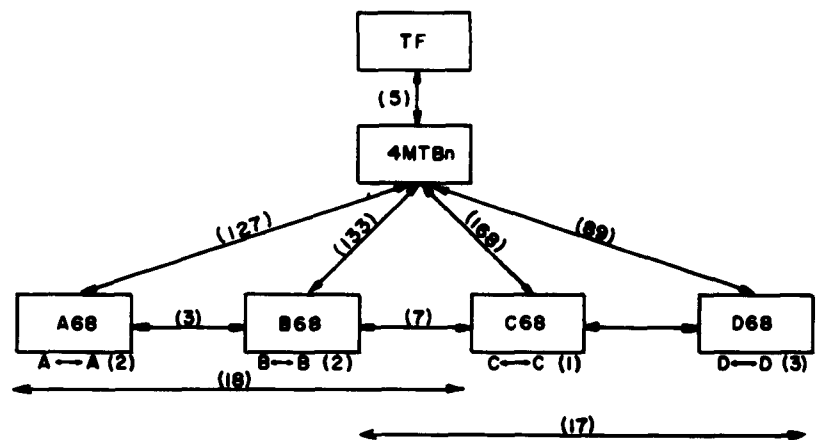


Fig. 7—Conversation Distribution by Link, FTX 20-22 Oct 59

Message Function

The following discussion of the communications data is in terms of messages as previously defined in the section "Methodology."

Figure 8 shows the time distribution of messages throughout the exercise. During the hour from 1130 to 1230 on 22 Oct, 92 messages were classed as critical; these are indicated by the shaded areas in Fig. 8.

Figure 9 shows the time distribution of the classes of critical messages, a further breakdown of the shaded areas of Fig. 8. The hour from 1130 to 1230 on 22 Oct contained 65 critical messages of which 25 were command messages; 5 were weapons control; and 35 were intelligence messages; there were none of class 4 during this hour.

Table 10 shows the more detailed breakdown of the function classes of messages and the percentage of each class with respect to the total number of messages sent. In this table it is shown that intelligence messages formed 36.6 percent of the total and 59.3 percent of the critical-message activity.

Messages per Conversations

Table 11 shows the number of conversations containing x component messages (x ranges from 0 to 7). The term message denotes a communication

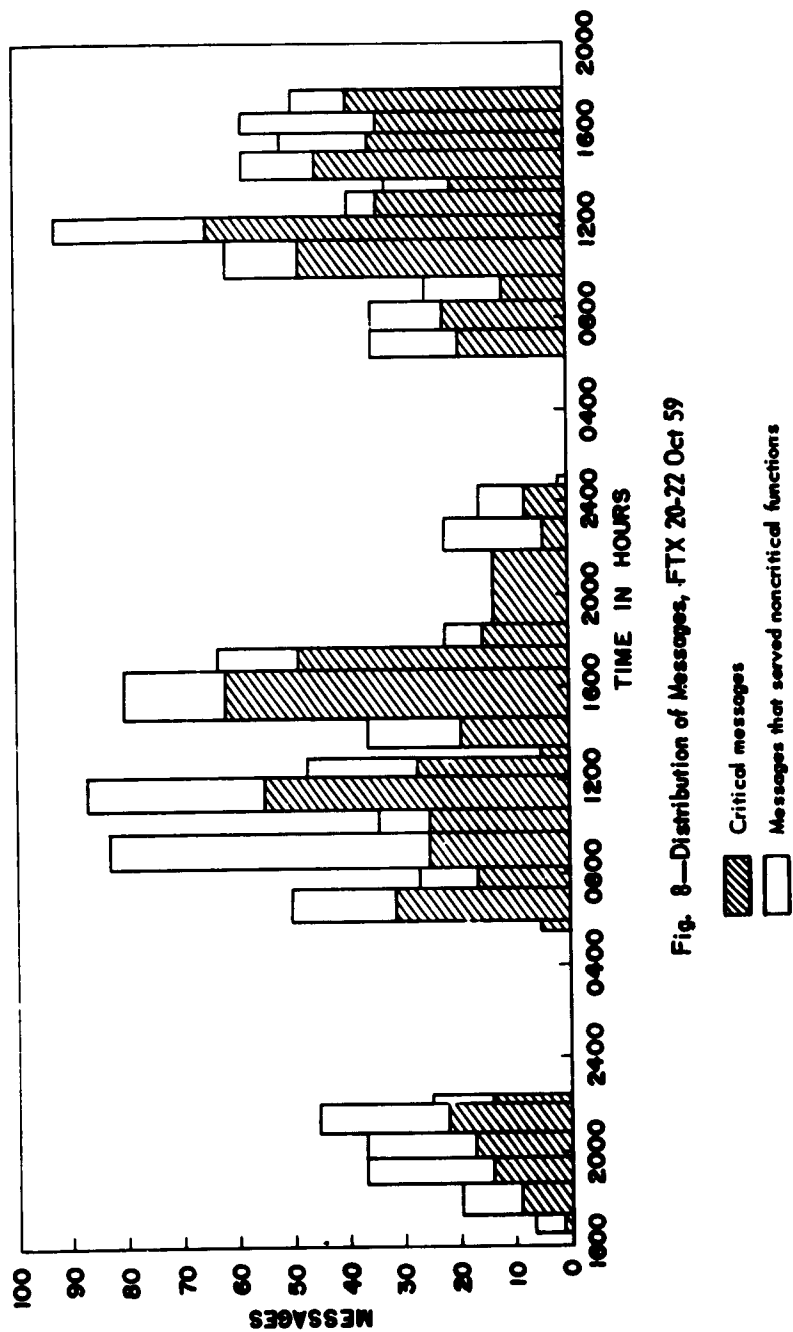


Fig. 8—Distribution of Messages, FTX 20-22 Oct 59

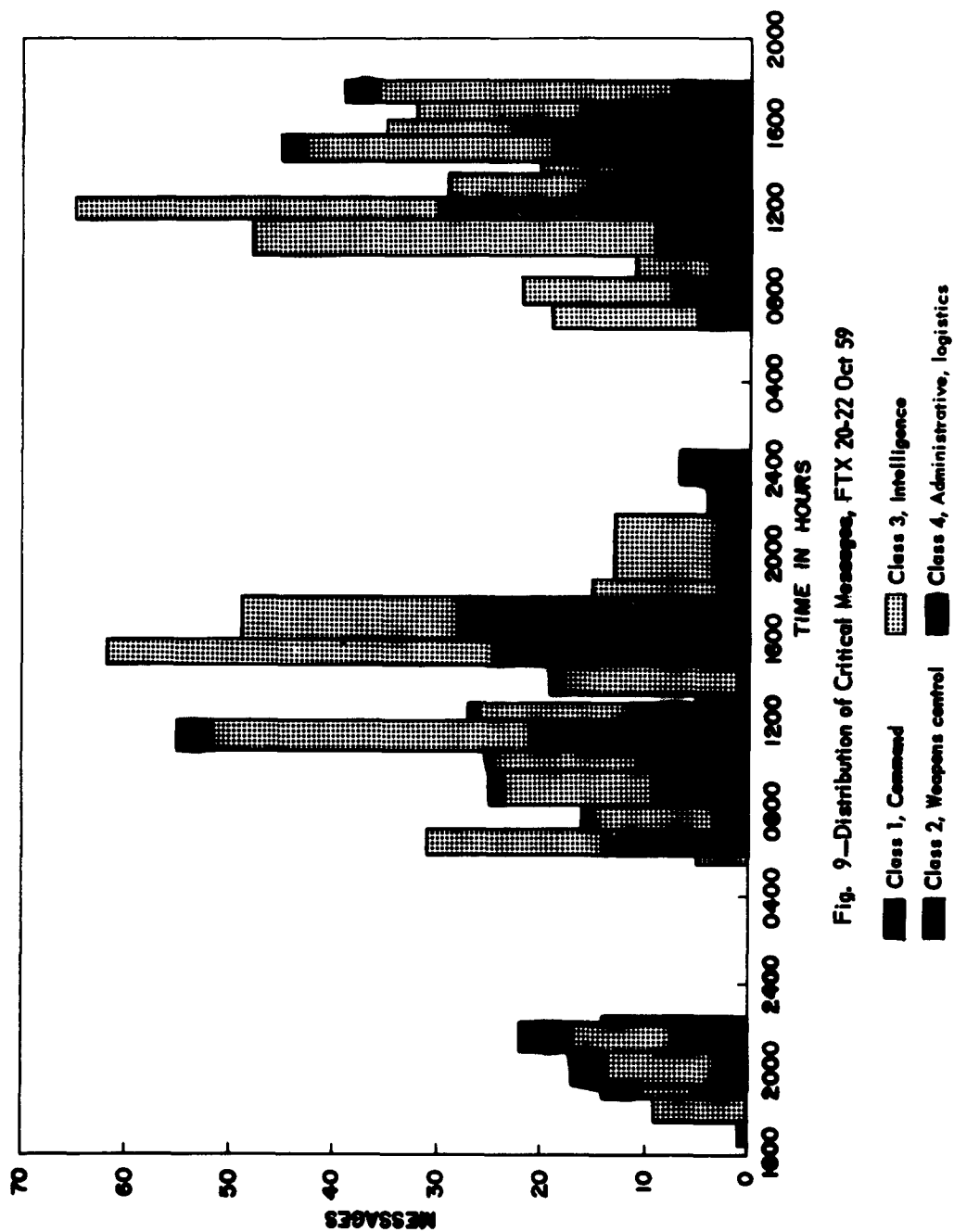


Fig. 9—Distribution of Critical Messages, FTX 20-22 Oct 59

TABLE 10
MESSAGE DISTRIBUTION BY CLASS,
FTX 20-22 OCT 59

Class	Messages	Percent of total
Command (1)	276	21.2
Weapons (2)	23	1.8
Intelligence (3)	477	36.6
Administrative, logistics (4)	28	2.2
Noncritical (NC)	269	20.6
Unanswered calls (UN)	136	10.4
Repeat request (Rp Rq)	44	3.4
Obscured (Obs)	52	3.9
Total	1305	100

TABLE 11
MESSAGES PER CONVERSATION,
FTX 20-22 OCT 59

x	Conversations having x component messages	Percent
0 ^a	190	22.1
1	379	44.1
2	187	21.8
3	70	8.1
4	22	2.6
5	5	0.6
6	4	0.5
7	2	0.2
Total	859	100

^aThe 190 conversations listed as having no component messages were those consisting solely of an exchange of call signs and others in which a message was exchanged but was unintelligible on the tape recording.

serving one function. The table shows that 22.1 percent of the conversations contained no messages, i.e., conversations whose message content was obscured, conversations consisting of an exchange of call signs, etc. The average number of messages per conversation was 1.5.

Ranges

The range data for this exercise were obtained exclusively from the photographs of the maneuver overlays. It was found that all the observable Bn ↔ Co ranges for 20-22 Oct were 12 km or less. Ninety-three percent of the ranges were 11 km or less; 75 percent were 9 km or less. From the available data for this maneuver no further resolution was possible.

Links

Table 12 shows the conversation per link hour for the various type-links monitored. It is shown that the Bn ↔ Tk Co links carried an average of 3.4 conversations/link hour. The battalion command-net message and conversation data indicated an average of 1.5 messages/conversation, and an average of 0.9 critical message/conversation.

TABLE 12
CONVERSATIONS PER LINK HOUR, FTX 20-22 OCT 59

Link	Conversations	Link hours	Conversation per link hour
Gp ↔ Bn	5	36.5	0.2
Bn ↔ Tk Co	489	146.0	3.4
Bn ↔ A68	127	36.5	3.4
Bn ↔ B68	133	36.5	3.6
Bn ↔ C68	140	36.5	3.8
Bn ↔ C68	89	36.5	2.2

The battalion command net carried an average of 35.8 messages/hr; an average of 22 critical messages/hr were carried by this net.

The conversation data indicate an average of 23.5 conversations/hr on the battalion command net. The Bn ↔ Tk Co links each carried an average of 5.3 messages/hr/link.

3D MED TK BN COMMAND NET: FTX 28-31 OCT 59

INTRODUCTION

The 3d Med Tk Bn (Patton) of the 32d Armd Regt was tested in an FTX on 28-31 Oct 59 at Ft Stewart, Ga. The communications traffic on the battalion command net was monitored from 281800 Oct until 311000 Oct; this resulted in approximately 35.5 hr of tape-recorded traffic. The tested battalion and its attached units formed a tank-heavy battalion task force known in this exercise as TF Spur (see App A for combat organization).

The enemy situation at the beginning of the exercise assumed that the aggressor 3d Mecz Army had broken out of a bridgehead and was reorganizing. Elements of the 3d Mecz Army were considered to be in the vicinity of Hinesville where they were opposing the friendly 1st Inf Div; elements of the 16th Mecz Rifle Div were in contact with the 2d Inf Div about 20 km north of Hinesville.

Operation

The exercise consisted of three phases that were effected in the western third of the reservation area. During the first phase TF Spur marched to and occupied defensive positions in the northwestern corner of the reservation to deny critical terrain to the enemy and to canalize the aggressor into Killing Ground Knockout. In the second phase TF Spur organized initial delay positions and conducted a delaying action on successive delaying positions. During the third phase TF Spur attacked southwestward from a position on the western border of the reservation with the mission of seizing the Ft Stewart cantonment.

Phase 1. The first phase of the exercise centered around Killing Ground Knockout near the northern border of the reservation on FS* Road 17. TF Spur executed a fixing mission with the object of initially defending along the FEBA (Highway 67) and then fixing the aggressor in Killing Ground Knockout. To accomplish this mission, three companies (A, B, C) of the TF Spur were placed in position just west of Highway 67; the fourth company (D) and the battalion headquarters were located in the killing ground area about 8 km west of the FEBA.

*The improved light-duty roads within the boundaries of Ft Stewart are identified on the AMS sheets by the letters FS followed by the number of the road.

On 29 Oct the patrol action continued and C Co, under infantry attack at 0735, was forced to withdraw at 0746; the requested artillery concentration seemed to have no effect. The action on 28 Oct seems to have been confined to light aggressor probing action.

At 0820, the US forces fired a nuclear airburst.

At 1150 the friendly units were given an air reconnaissance report on the aggressor's position.

Phase 2. The communications activity of Phase 2 of the exercise began at 0700 on 30 Oct. The 2d Armd Div conducted a northwestward withdrawal in their zone, two combat commands abreast. The mission included holding the aggressor south of Camp Oliver until 1700 on 30 Oct.

TF Spur's part in the mission was to organize initial delay positions by 0700 on 30 Oct and then to conduct a delaying action through successive delaying positions with the purpose of holding the aggressor south and east of Camp Oliver until 1700 on 30 Oct.

At 0815 Co A reported that the aggressor had penetrated the mine field and that artillery had been ineffective against the advance. At 0820 and 0907 Co C reported gas attacks by the enemy. At 0840 Co C reported an aggressor tactical air strike—no casualties. At 1146 a report came in that Cos B and C had been at the ground zero of an aggressor nuclear burst.

Phase 3. The third phase of the exercise involved the 2d Armd Div attacking through the 1st and 2d Inf Div with the mission of seizing Ft Stewart, Willie, and Pembroke. The operation was a penetration in the zone of the first battle group in the southwest corner of the reservation on multiple axes. Communications began at 0700 and ended with the completion of the exercise at 1000.

Weather and Visibility Conditions

The pattern of rainy weather during the preceding maneuvers held true for this, the final exercise considered in this paper. Heavy rain on the second and

TABLE 13
PRECIPITATION AND TEMPERATURE
DATA, 22-31 OCT 59

Date	Total precipitation ^a	Temperature, °F	
		Maximum	Minimum
22	0.65	70	63
23	0.40	78	64
24	0.10	75	63
25		68	47
26		75	42
27	0.03	80	54
28		67	52
29	1.10	64	56
30	1.12	70	61
31	T ^b	80	65

^aTotal precipitation, in inches, measured during the 24-hr period ending at 1900 on the indicated day.

^bT, trace, an amount too small to measure.

third days of the exercise (as shown in Table 13) again had considerable adverse effect on the road conditions and on off-road travel.

DATA

In the following discussion the previous definitions will be used in regard to conversations, messages, etc. The uneven distribution of time checks on the tape recording resulted in intervals of irregular length.

Traffic Count

Table 14 shows the results of a traffic count of the recorded conversations. The conversations in which one or more of the stations were unidentified were again distributed proportionately to arrive at an adjusted distribution of conversation activity. This table indicates that 15.7 percent of the conversations did not include the identity of at least one of the nodes of the link carrying the conversation.

TABLE 14
BATTALION COMMAND NET: CONVERSATION DISTRIBUTION
BY TYPE-LINK, FTX 28-31 OCT 59

Link	Unadjusted distribution		Adjusted distribution	
	Conversations	Percent of total	Conversations	Percent of total
Gp ↔ Gp (internal)	8	0.8	8	0.8
Bn ↔ Bn (internal)	90	9.2	106	10.8
Co ↔ Co	78	7.9	82	8.4
Gp ↔ Bn	27	2.8	33	3.4
Bn ↔ Co	623	63.4	752	76.6
Gp ↔ Co	1	0.1	1	0.1
Bn ↔ unidentified	116	11.8		
Co ↔ unidentified	20	2.0		
Unidentified ↔ unidentified	19	1.9		
Total	982	100	982	100

Figure 10 shows the distribution of the conversation activity over the 4-day duration of the maneuver. The busy hour was on 31 Oct (0847-1000); during this time 146 conversations took place, of which 86 were between a battalion station and a company station. Considerable dead space is shown on Fig. 10.

Figure 11 shows the number of conversations recorded during the maneuver on each of the links. The Bn ↔ Co D link was the most active with 166 conversations; the Bn ↔ HQ Co link was the least active with 44 conversations. The least active Bn ↔ Tk Co link differed by a factor of about 1.4 from the most active link. There were 27 recorded Gp ↔ Bn conversations during the exercise.

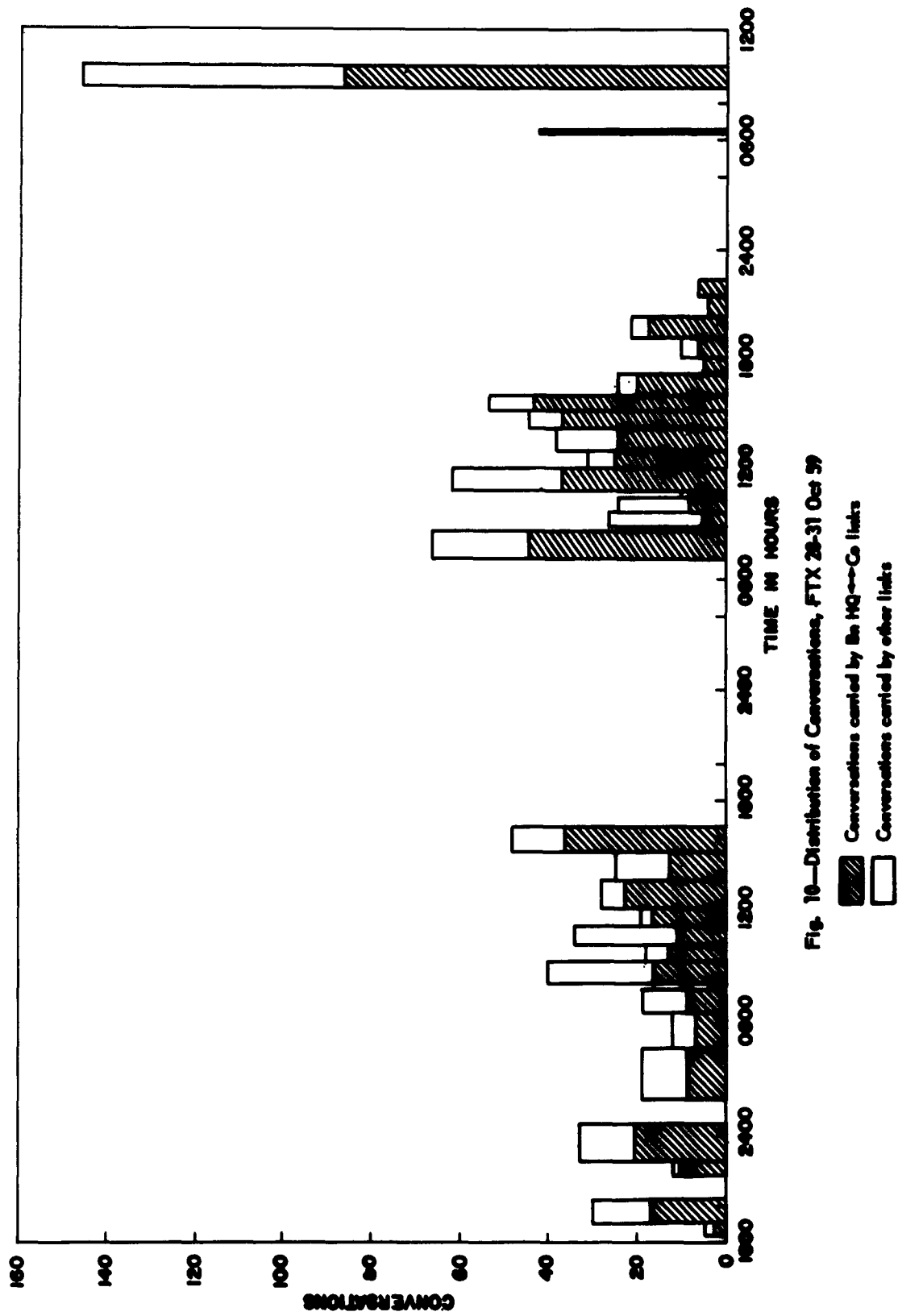


Fig. 10—Distribution of Conversations, FTX 28-31 Oct 59

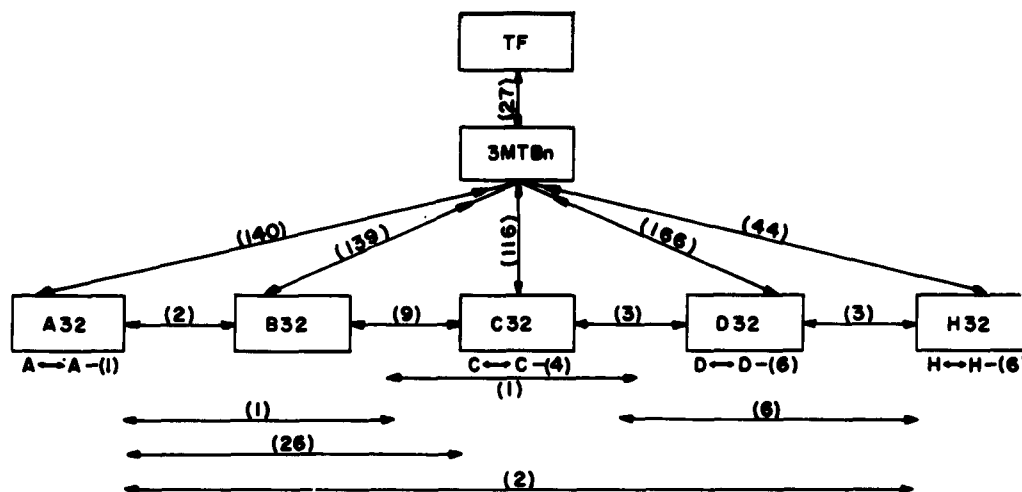


Fig. 11—Conversation Distribution by Link, FTX 28-31 Oct 59

TABLE 15
MESSAGE DISTRIBUTION BY CLASS, FTX 28-31 OCT 59

Class	Messages	Percent of total
Command (1)	355	23.6
Weapons (2)	64	4.3
Intelligence (3)	569	37.8
Administrative, logistics (4)	21	1.4
Noncritical (NC)	212	14.1
Unanswered (UN)	120	8.0
Repeat request (Rp Rq)	61	4.1
Obscured (Obs)	102	6.8
Total	1504	100

Message Function

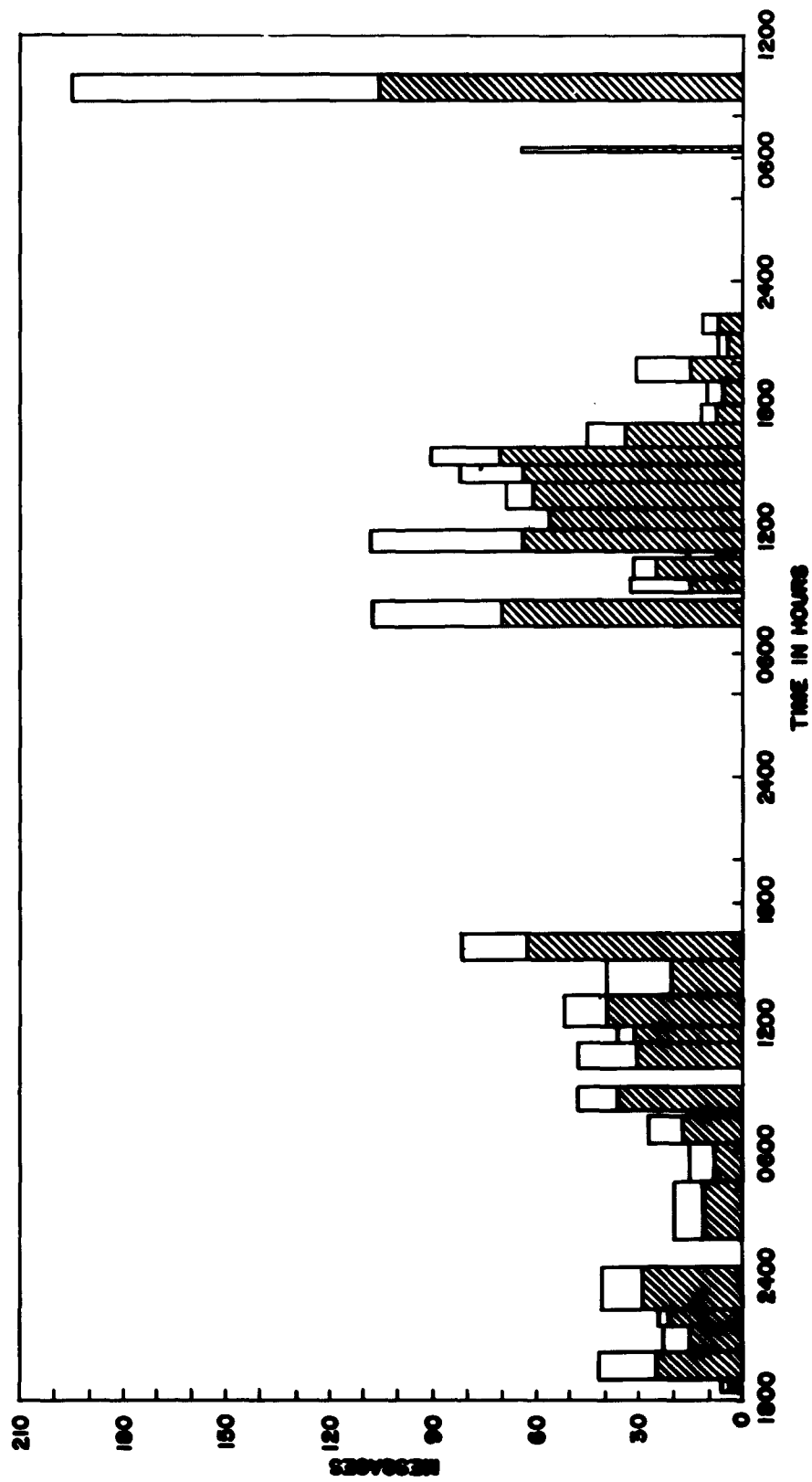
The following discussion of the communications data will be in terms of message function as previously defined.

Table 15 shows the number of messages of each function class recorded during the exercise. The intelligence class again forms the largest group.

Figure 12 shows the distribution of recorded messages for the maneuver, the shaded area indicating the number of critical messages recorded during each interval. The busy hour from 0837 to 1000 on 31 Oct shows 194 messages; 105 of these were critical.

The critical messages were broken down, as shown in Fig. 13, into function classes 1, 2, 3, 4.

The intelligence messages formed 37.8 percent of the total message activity and 56.3 percent of the critical messages.



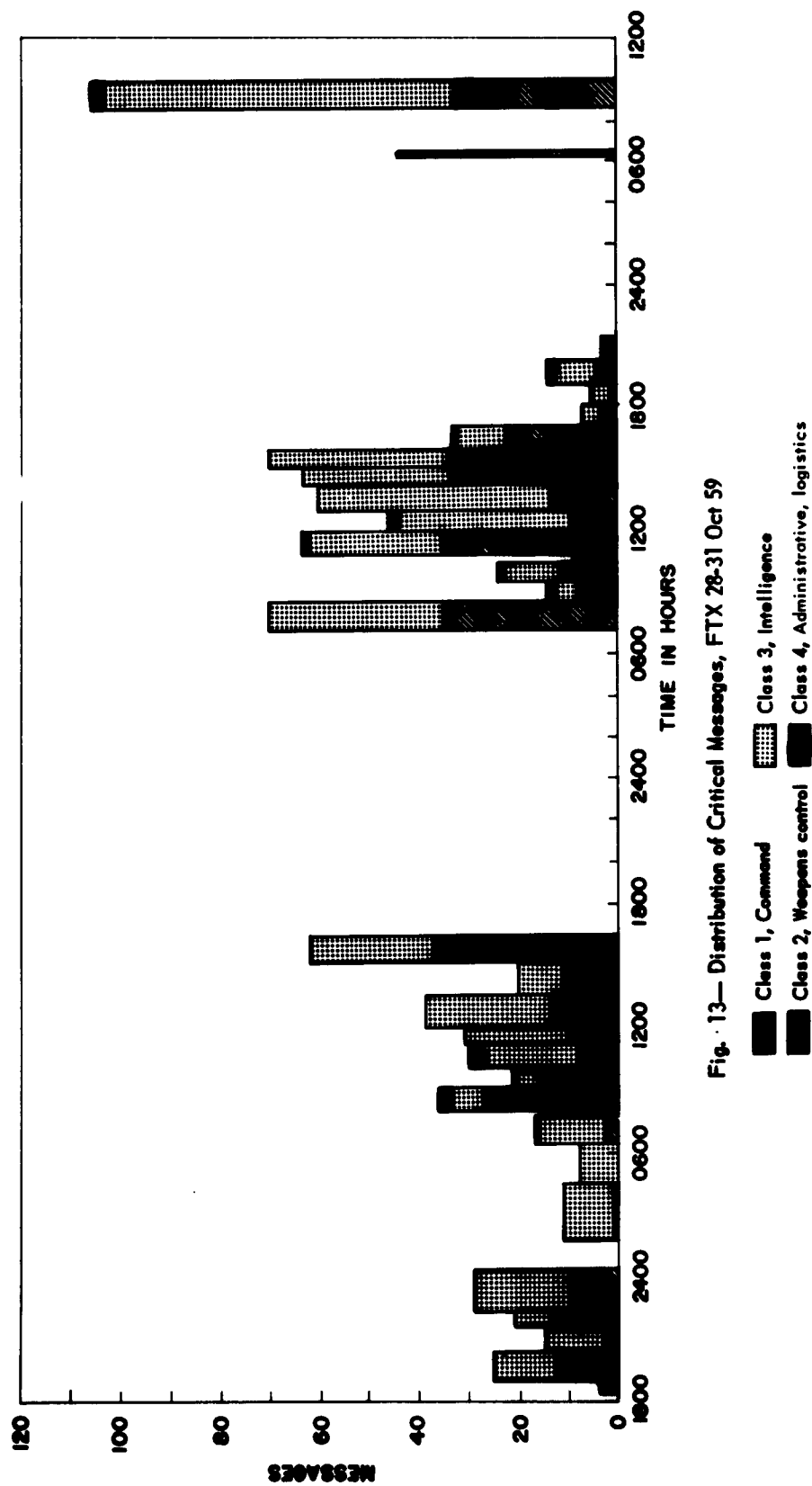


Fig. 13— Distribution of Critical Messages, FTX 28-31 Oct 59

Messages per Conversation

Table 16 shows the number of conversations containing x component messages. The table shows that 22.3 percent of the conversations contained no messages, i.e., conversations in which the message was obscured, or conversations consisting only of an exchange of call signs, etc. The average number of messages per conversation was 1.5; the critical messages averaged 0.7 per conversation.

TABLE 16
MESSAGES PER CONVERSATION,
FTX 28-31 OCT 59

x	Conversations having x component messages	Percent
0 ^a	219	22.3
1	428	43.6
2	216	22.0
3	70	7.1
4	36	3.7
5	8	0.8
6	4	0.4
7	1	0.1
Total	982	100

^aThe 219 conversations listed as having no component messages were those consisting solely of an exchange of call signs and others in which a message was exchanged but was unintelligible on the tape recording.

TABLE 17
CONVERSATIONS PER LINK HOUR, FTX 28-31 OCT 59

Link	Conversations	Link hours	Conversations per link hour
Gp ↔ Bn	27	35.5	0.8
Bn ↔ Co	623	177.5	3.6
Bn ↔ Tk Co	579	142.0	4.0
Bn ↔ A32	145	35.5	4.0
Bn ↔ B32	143	35.5	4.0
Bn ↔ C32	120	35.5	3.4
Bn ↔ D32	171	35.5	4.8
Bn ↔ H32	44	35.5	1.2

Ranges

The ranges observed for the Bn ↔ Tk Co link in this exercise indicates that the maximum Bn HQ ↔ Tk Co ranges was 12 km; approximately 90 percent of the ranges were 9 km or less. The range data did not permit further resolution.

Links

Table 17 shows the conversations per link interval for the third exercise; the Bn ↔ Tk Co links carried approximately 4 conversations/link hour.

The battalion command net carried an average of 42 messages/hr of which 28 were critical. These messages formed an average of 27.6 conversations/hr.

The Bn ↔ Tk Co links carried an average of 6.2 messages/hr.

COMPARISON

This section compares the results of the three exercises presented in the previous sections of this paper and contrasts these with some of the results of the first INDIGO game. Only INDIGO I is considered here since in this first play of the game three tank groups were played, all roughly similar in organization to a tank battalion. In the second and third plays of INDIGO no units were played that could be compared validly with a tank battalion (see App A for combat organization).

OPERATION

Ft Stewart

The first exercise was a CPX in which only the command elements were in the field; the second and third exercises involved an actual medium tank battalion and a live aggressor. The area of operation in the first maneuver was confined to the eastern third of the reservation after an initial march of about 60 km from Camp Oliver. In the second exercise the operation again was initiated at Camp Oliver but for the most part was confined to the southwest corner of the reservation. The third maneuver also started at Camp Oliver and covered the western third of the reservation. The typical front for the battalion task force in each of the FTXs was 12 km.

The phases of operation in the first exercise, which involved only the command elements, were a tactical march of 60.5 km, a counterattack and a withdrawal. The second maneuver had a tactical march of about 17 km (there are no communications data for this phase), a fixing mission, a delaying phase, and a counterattack phase (not monitored). The third exercise went through an initial phase consisting of a short march followed by emplacement in defensive positions, a second phase of withdrawal, and a final counterattack phase.

Complete data on simulated nuclear employment are not available; however, each of the three exercises included simulated nuclear low airbursts.

The weather during the three exercises was unfavorable; a heavy rain 13 Sep preceded the first exercise and light rain followed on the 2 days of operations; the second maneuver had moderate rainfall 21 and 22 Oct; the third maneuver had 2 days of heavy rainfall. Temperatures ranged from a low of 52°F to a high of 82°F during the three exercises.

INDIGO I

"INDIGO I is concerned with the operations of a US Army infantry division (Blue), reinforced by a tank brigade and other supporting units from corps and field army, and a Soviet combined-arms corps (Red) in June 1965."¹ The game simulated a conflict in a 140- by 35-km rectangular area in southwest Germany. The trafficability of this area was considered good for a military operation, in strong contrast with the swampy conditions found at Ft Stewart. The weather was considered good for this play of INDIGO, whereas rainy conditions prevailed at Ft Stewart.

The game began at 191200 Jun 65. At this time the companies of the 41st Tk Gp were the only tank units in play; however, only two of the companies were assigned to the 41st.² At 1900 the 42d Tk Gp was introduced and at 2000 the 43d Tk Gp entered the game; the entry of these units coincided with the completion of the development phase of the game. The 42d remained as a unit in the division reserve area from 192000 to 200100, when two of its companies were assigned to Combat Team 41; at this time the 42d and the two remaining companies moved toward the FEBA. At 200400 the 43d Tk Gp moved toward the FEBA from its position in the division rear as part of the Blue spoiling attack. The game was concluded at 200800 Jun 65. The game provides Tk Gp ↔ Tk Co range data for the 42d Tk Gp as a unit from 1900 to 0100 and similar data for the 43d Tk Gp from 2000 until the conclusion of the game.

DATA

Traffic Count

The traffic count results were based on three records ranging in length from 15 hr for the first exercise to 36.5 for the second, and 35.5 hr for the third. The first exercise, as has been mentioned, involved only the command elements; the units being tested in the second and third exercises were of battalion strength plus attachments. It will be recalled that the notation Gp ↔ Gp (internal) indicated the conversations in which the participants were stations of the combat group headquarters to which the tested battalion was considered to be assigned. Also the notation Bn ↔ Bn (internal) indicates the number of conversations that passed between two stations of the tested battalion's headquarters.

Table 18 summarizes for comparison the values included in the adjusted columns of Tables 4, 9, and 14. The table shows the similarity between the results of the two FTXs. When compared to the FTXs the results of the CPX seem to be weighted very lightly (37.5 percent vs an average of 74.9 percent) in the number of recorded Bn ↔ Co conversations, and very heavily (28.1 percent vs an average of 2.2 percent) in the Gp ↔ Bn conversations.

The busy hour in the first exercise (151405-151505 Sep) contained 101 conversations of which 33.3 percent were Bn ↔ Co; in the second exercise the busy hour (211050-211205 Oct) carried 61 conversations of which 47.5 percent were Bn ↔ Co; in the last exercise, the busy hour (310847-311000 Oct) contained 146 conversations of which 58.9 percent were carried by Bn ↔ Co links. The busy hour in INDIGO I for the Tk Gp ↔ Tk Co link occurred at

TABLE 18
CONVERSATION DISTRIBUTION^a BY TYPE-LINK

Link	14-15 Sep 59		20-22 Oct 59		28-31 Oct 59	
	No.	Percent	No.	Percent	No.	Percent
Gp ↔ Gp (internal)	5	0.8	7	0.8	8	0.8
Ba ↔ Ba (internal)	167	25.6	139	16.2	106	10.8
Co ↔ Co	48	7.4	78	9.1	82	8.4
Gp ↔ Ba	183	28.1	6	0.7	33	3.4
Ba ↔ Co	244	37.5	629	73.2	752	76.6
Gp ↔ Co	4	0.6	—	—	1	0.1
Total	651	100	859	100	982	100

^aThese are the adjusted distributions from Tables 4, 9, and 14.

0700 during the containment of Blue's spoiling attack and the progress of Red's 19th Div attack.

Messages per Conversation

Figure 14 summarizes the average number of messages per conversation for the three exercises. Tables 11 and 16 show extremely close relations between the messages-per-conversation distributions for the two FTXs; the CPX deviates slightly, particularly in the percentage of conversations having 0, 1, 2, or 3 component messages. A total of 2492 conversations was counted during the three exercises. Figure 14 shows that an average of 46.6 percent (1146) of the conversations in the three maneuvers had one component message; also that 591 conversations (24.1 percent) had no component messages and either consisted of an exchange of call signs or had message content that was unintelligible to the transcriber. There were 1901 conversations that contained

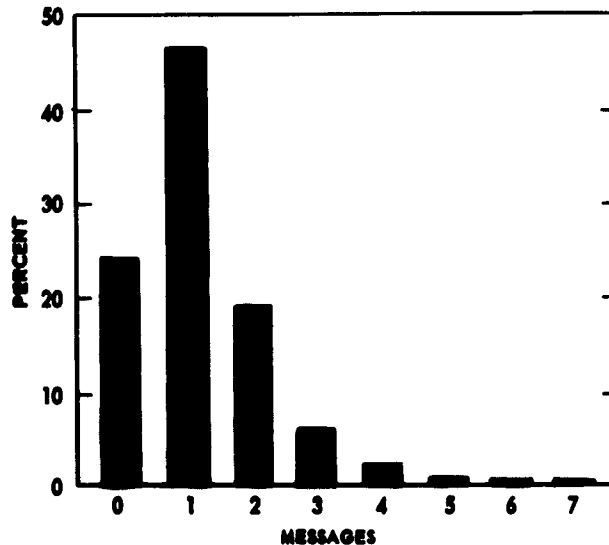


Fig. 14—Average Messages per Conversation for the Three Exercises Studied

intelligible messages. Of these, 60 percent contained 1, 26 percent contained 2, 9 percent contained 3, and 4 percent contained 4 messages. The largest number of messages in a single conversation was seven.

Message Function

The intelligence messages sent in INDIGO I generally represented the intelligence information sent up the chain of command. Intelligence flowing down the chain of command to lower-echelon units was considered unrealistic since the player's table served as the G2 map; this made the intelligence information visible to all Blue players.³ However, the downward flow of intelligence was simulated by the addition of 1 message/hr to the existing division headquarters ↔ brigade, group, and battalion headquarters links. If this method were carried a step further, so that each intelligence message reaching a group headquarters resulted in a message being sent to each company attached to that group, there would be 88 additional Tk Gp ↔ Tk Co intelligence messages in INDIGO I. This would result in 43 percent of the messages carried by the Tk Gp ↔ Tk Co links being command messages, 3 percent weapons control, and 54 percent intelligence messages.

The intelligence message figures for the field exercises represent both the upward and downward flow of intelligence. Thus when the INDIGO figures are compared with the results of the exercises in Table 19 the percentage of command messages in INDIGO I is exaggerated. However, an average of 31 percent of the messages of classes 1, 2, and 3 sent during the three exercises

TABLE 19
MESSAGE DISTRIBUTION BY CLASS FOR THE
THREE EXERCISES STUDIED

Class	14-15 Sep 59		20-22 Oct 59		28-31 Oct 59		INDIGO I ^a	
	No.	Percent	No.	Percent	No.	Percent	No.	Percent
1	78	9.2	276	21.2	355	23.6	149	58
2	28	3.3	23	1.8	64	4.3	10	4
3	277	32.8	477	36.6	569	37.8	97	38
4	2	0.2	28	2.2	21	1.4		
NC	244	29.0	269	20.6	212	14.1		
UN	146	17.3	136	10.4	120	8.0		
Rp rq	34	4.0	44	3.4	61	4.1		
Obs	36	4.3	52	3.9	102	5.8		
Total	845	100	1305	100	1504	100	256	100

^aThese are the figures for the Tk Gp ↔ Tk Co link in INDIGO I

were command, 6 percent were weapons control, and 63 percent were intelligence messages. The magnitude of these figures is similar to that of the hypothetical results mentioned in the preceding paragraph.

Table 20 shows the message-function ratios for classes 1, 2, and 3 in the three exercises and the Tk Gp ↔ Tk Co link in INDIGO I.

TABLE 20
MESSAGE FUNCTION RATIO

Date	Function		
	Command (1)	Weapons control (2)	Intelligence (3)
14-15 Sep 59	3	1	10
20-22 Oct 59	12	1	21
28-31 Oct 59	6	1	9
INDIGO I ^a	15	1	10

^aThis is the ratio for the Tk Gp ↔ Tk Co link.

Figures 4, 8, and 12 show the distribution of total message activity throughout the maneuvers as well as the fraction accounted for by the critical messages sent during a given time period. Here again the two FTXs agree (61.8 percent and 63.0 percent) very closely in the percentage of critical messages in the total number of recorded messages; the CPK had 45.9 percent critical. The messages in INDIGO I were of course considered to be 100 percent critical.

The hour having the most messages coincided with the conversation busy hour in the CPK; in the second exercise the hour containing the most (82) messages (221130-221230 Oct) does not coincide with the conversation busy hour (which contained 87 messages); in the third exercise the hour of greatest message activity again coincides with the conversation busy hour.

A comparison of Figs. 5, 9, 13, which show the critical messages broken down into the message function for each time period, reveals a noticeable increase in the number of critical and intelligence messages as we go from the beginning of each exercise toward the end; there are peaks of activity 2 hr before the end of the first, 6 hr before the end of the second, and at the close of the exercise on the third.

Links

Table 21 shows the conversations per link hour for the particular links for which recorded data are available. There is considerable agreement

TABLE 21
CONVERSATIONS PER LINK HOUR FOR THE
THREE EXERCISES STUDIED

Link	14-15 Sep	20-22 Oct	28-31 Oct
Gp ↔ Bn	12.6	0.2	0.8
Bn ↔ Tk Co	3.8	3.4	3.6
Bn ↔ Co	3.4	3.6 ^a	4.0
Bn ↔ Co A	2.2	3.4	4.0
Bn ↔ Co B	4.0	3.6	4.0
Bn ↔ Co C	4.0	3.8	3.4
Bn ↔ Co D	4.2	2.4	4.8
Bn ↔ Co H	1.4	^a	1.2

^aThere was no recorded conversation activity on the Bn ↔ HQ Co link during this exercise.

within the table with the exception of the results for the two FTXs and the CPX in the case of the Gp ↔ Bn link; and the Bn ↔ Co D results for the 3d Bn and the 4th Bn. For the maneuvers as a whole there was an average of 3.6 conversations/link hour for the Bn ↔ Tk Co links.

Table 22 shows the number of critical messages per link hour for the three exercises and INDIGO I. The Ft Stewart results had an average of 2.9 critical messages/link/hour; the INDIGO Tk Gp ↔ Tk Co results showed an average of 2.3.

TABLE 22
CRITICAL MESSAGES PER LINK PER HOUR

Exercise	Critical messages	Link hours	Critical messages per link per hour
INDIGO I ^a	256	109	2.3
14-15 Sep 59	385	208	1.9
20-22 Oct 59	804	251	3.2
29-31 Oct 59	1009	280	3.6

^aThese are the figures for the Tk Gp ↔ Tk Co link in INDIGO I.

TABLE 23
MESSAGE-CONVERSATION RELATIONS^a

Date of exercise	Messages per conversation	Critical messages per conversation	Bn ↔ Tk Co conversations per hour	Messages per hour	Critical messages per hour	Messages per hour per Tk Co link	Critical Bn ↔ Tk Co messages per hour
14-15 Sep 59	1.3	0.6	43.4	56.3	25.6	4.9	8.9
20-22 Oct 59	1.5	0.9	23.5	35.8	22.0	5.3	12.7
28-31 Oct 59	1.5	0.7	27.6	42.3	28.3	6.2	11.1

^aFigures represent results for the recorded battalion command-net communications as a whole.

Table 23 shows the relation between some of the ratios computed on the basis of the recorded data; the results of the FTXs as well as those of the CPX are similar. The number of critical conversations per hour and the number of Bn ↔ Co conversations per hour agree closely for the three exercises.

Ranges

Determination of the distances between each of the companies and the battalion headquarters was hampered by a lack of sufficient data. However, an upper limit on the ranges was indicated: 12 km as a maximum Bn ↔ Tk Co range.

In INDIGO I, 95 percent of the Tk Gp ↔ Tk Co ranges for the 43 Tk Gp were ≤23 km; 80 percent were ≤15 km (the maximum range noted was 26 km). The range figures for the 42d Tk Gp from 1900 to 0100 are also comparable to the results for a tank battalion acting as a unit; 92 percent of the ranges for the 42d were ≤14 km (the maximum range noted was 16 km).

Appendix A

COMBAT ORGANIZATION

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DISCUSSION

The first three figures in this appendix indicate the combat organization of the medium tank battalions whose communications were monitored at Ft Stewart, Ga. The fourth figure shows the typical organization of the tank groups played in INDIGO I. The communications of these units when played as tank groups may be validly compared with the communications of a medium tank battalion. The fifth and sixth figures illustrate the distribution of the tank companies in units composed predominantly of infantry in INDIGO II and III. The communication results for these organizations were regarded as unsuitable for comparison with those of Ft Stewart and INDIGO I.

COMBAT ORGANIZATION ABBREVIATIONS

14-15 Sep 59

TFC	task force control
3MTBn	3d Med Tk Bn (Patton), 32d Armd Regt
A32	Co A, 3d Med Tk Bn (also B32, C32, and D32)
H32	HQ Co, 3d Med Tk Bn
1A3	1st Plat, Co A, 3d BG (also 2A3 and 4A3)
A353	Co A (-), 353d Engr Bn
1A353	1st Plat, Co A, 353d Engr Bn (also 2A353)
A83	Btry A, 83d FA Bn
1M32	Mort Plat, 3d Med Tk Bn
1R32	Sct Plat, 3d Med Tk Bn

20-22 Oct 59

TFC	task force control
Recon	reconnaissance platoon
Mtr	mortar platoon
Engr	engineer platoon
IPW	prisoner of war interrogation team
A187(-)	Co A, 187th Inf
4MTBn	4th Med Tk Bn (Patton), 68th Armd Regt
A68	Co A, 4th Med Tk Bn (also B68, C68, and D68)
1A187	1st Plat, Co A, 187th Inf (also 2A187, 3A187, and 4A187)
Wpns A187	Wpns Plat, 187th Inf
FO1	FO Team, 187th Inf (also FO2 and FO3)

28-31 Oct 59

TFC	task force control
Recon	reconnaissance platoon
B187	Co B, 187th Inf
MTR	mortar platoon
1C169	1st Plat, Co C, 169th Engr
3MTBn	3d Med Tk Bn (Patton), 32d Armd Regt
A32	Co A, 3d Med Tk Bn (also B32, C32, and D32)
1B187	1st Plat, Co B, 187th Inf (also 2B187, 3B187, and 4B187)

INDIGO I

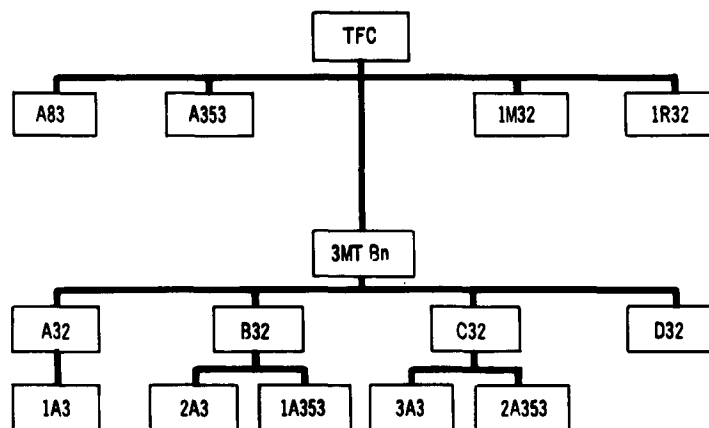
43TkGp	43d Tk Gp HQ
A43	Tk Co, 43d Tk Gp (also B43, C43, and D43)
E43	Btry, 43d Tk Gp

INDIGO II

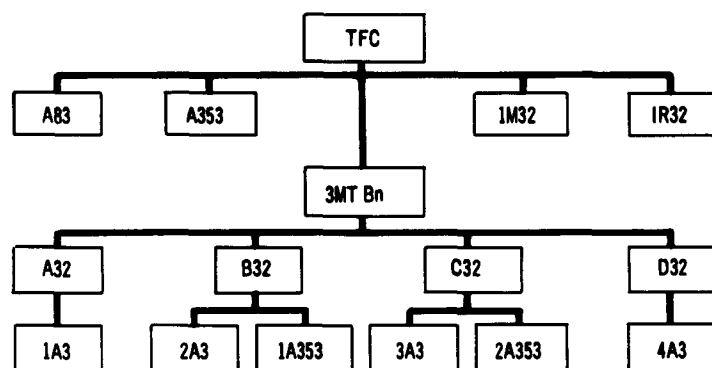
74	74th LCC
A74	Co A, 74th Mtz Inf (also B74, C74, and D74)
E74	Btry E, 74th LCC
2E74	DAVY CROCKETT Sqd, 74th C Gp (also 3E74 and 4E74)
R74	Combat Command Radar

INDIGO III

TF141	1st TF, 41st Med CC
A41	Co A, Mecz Inf (also B41)
C41	Co C (Tk), 41st Med CC



141500 Sep 59



150400 Sep 59

Fig. A1—Combat Organization: 3d Med Tk Bn, Sep 59

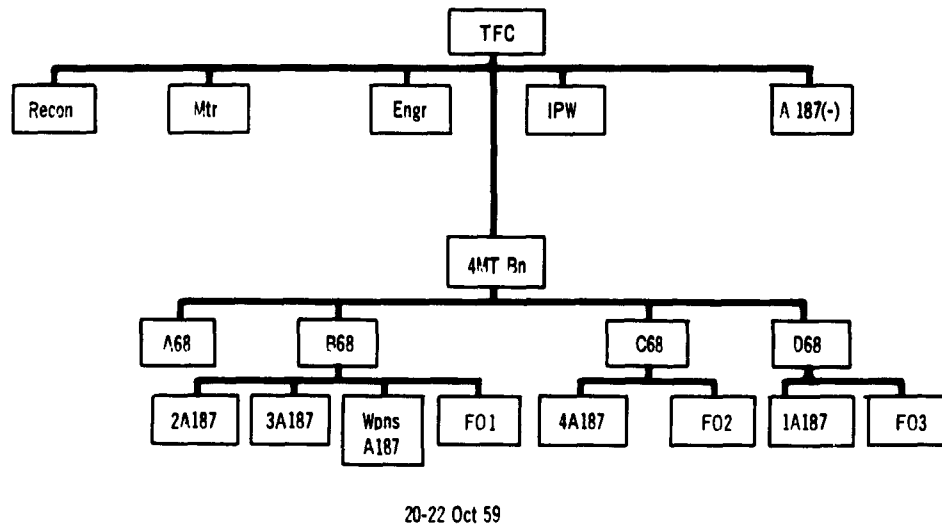


Fig. A2—Combat Organization: 4th Med Tk Bn, Oct 59

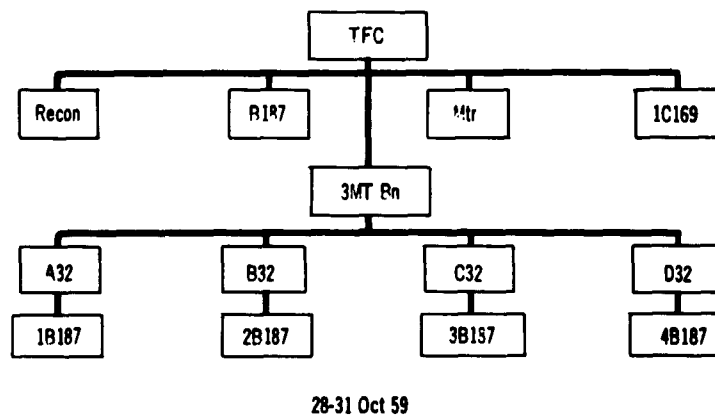


Fig. A3—Combat Organization: 3d Med Tk Bn, Oct 59

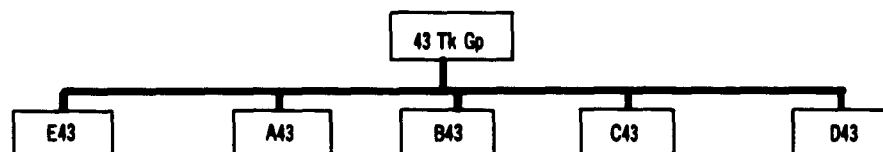


Fig. A4—Combat Organization: Indigo I - Tank Group

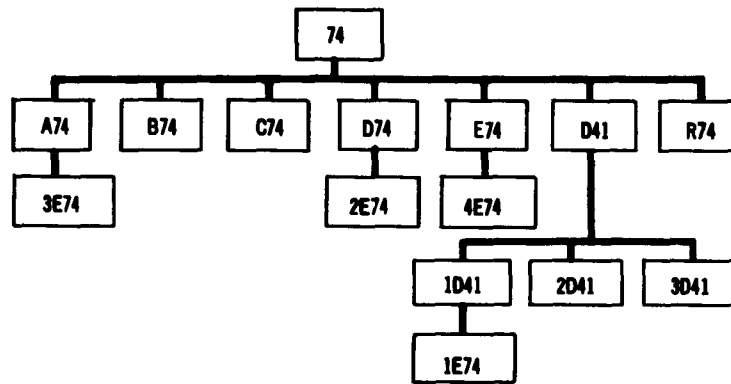


Fig. A5—Combat Organization: Indigo II - Combat Group

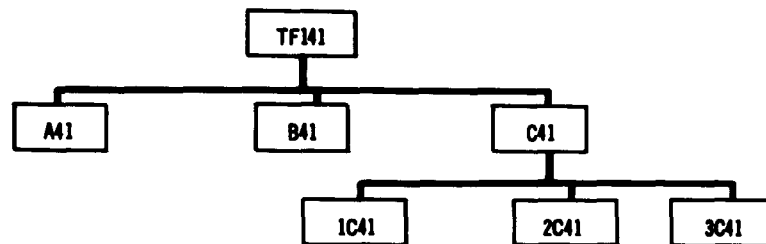


Fig. A6—Combat Organization: Indigo III - Task Force

Appendix B

GEOGRAPHY OF FT STEWART, GA.

DISCUSSION

~~TRAFFICABILITY — DRAINAGE — VEGETATION — CLIMATE~~

DISCUSSION

This geographical appendix is intended to be useful in comparing the communications results presented in this paper with those of other operations and simulations. Since the section "Geography of Ft Stewart" in the main body of this paper gives rather full information on the location, topography, and road and airfield systems of Ft Stewart, App B enlarges only on trafficability, drainage, vegetation, and climate.

Trafficability

Throughout the reservation the surface soils are primarily sandy, with some areas of silt and clay that reduce the permeability of the sand, producing poor soil drainage.

For movement off the roads and tank trails, the period from 1 May to 1 Nov is regarded as the dry season; even though the months of maximum precipitation are July, August, and September, the combined effect of the higher temperatures on the evaporation rate and the influence of the vegetation during the height of the growing season produces the periods of lowest soil moisture during these months. During this dry period the soil-slope conditions of many areas will support 40 medium tanks in trace although many of the same areas will be impassable for a single tank in the 1 Nov-1 May period.³

Most of the reservation is impassable for off-road traffic for at least half the year. Belts of terrain that are impassable the year round parallel the streams. Areas considered passable throughout the year are found only in the far western part of the reservation; the second and third exercises were conducted in this sector.

Drainage

The Canoochee River and two of its tributaries, Taylor's Creek and Canoochee Creek, drain most of Ft Stewart. The Canoochee River in turn is a tributary of the Ogeechee River, which forms the eastern boundary of the reservation.

A large part, perhaps 35 percent, of the area of the reservation is classified as swamp. The streams are characteristically bordered by belts of swampland.

Vegetation

Roughly 75 percent of the Ft Stewart reservation is forested—clearings are chiefly confined to the garrison areas, the several firing ranges, and the airstrips.

The vegetation type varies with the drainage characteristics of the soil. The fairly well-drained areas are generally covered with long-leaf pine and scrub oak. The moderately drained forested areas are covered with slash pine; wire grass and palmetto cover the less densely forested areas. Cypress, gum, and water oak are among the most common types of vegetation in the poorly drained areas.

The topography of Ft Stewart together with the many areas of dense vegetation seriously limits ground observation. The vegetation and forest restrict fields of fire for both low- and high-angle weapons and provide maximum concealment and cover.

The heavily wooded areas limit the use of nuclear weapons because of extensive burning and blowdown. Suitable open areas are very limited on the reservation.

Climate

The climate of Ft Stewart is considered semitropical. The area receives an average of 50 in. of precipitation a year (the annual precipitation in the period 1941-1952 ranged from a maximum of 67 in. to a minimum of 37 in.).

The annual temperature range is about 30° F—from an average of 82°F in July to 52°F in January. The mean maximum for July is 92°F; the mean minimum 71°F. The maximum for January is 65°F; the mean minimum 43°F.

Appendix C

DATA-COLLECTION OUTLINE

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DATA-COLLECTION OUTLINE	63

DISCUSSION

This appendix partly outlines the sources and types of information that were helpful or would have been helpful in preparing this paper. The outline has been included to provide a starting point or partial check list for persons who expect to monitor the communications during a future exercise and to indicate to army post personnel such individuals' probable areas of interest.

DATA-COLLECTION OUTLINE

The following papers prepared by or issued to umpires and/or commanders should be available to persons monitoring an exercise:

1. Operations order (together with modifications and hours during which the particular orders were in effect).
 2. Daily staff journal or duty officers log (together with action-taken code).
 3. Communications-net diagram.
 4. Signal operation instructions (the SOI in effect at the time of the maneuver).
 - a. Complete SOI giving the identity of the numerical suffixes of the call signs, i.e., Joy 80, Joy 46, etc.
 5. Check-point coordinate sheet used in the exercise.
 - a. If more than one set of check points is to be used, the days and hours that each set is to be in effect should be marked on the sheets.
 6. All available tracings of the command post overlay giving date and hour.
 7. Brevity code used in the exercise.
 8. Map-coordinate code used in the exercise.
 9. ATT work sheet.
 10. Operations plan (scenario), aggressor and friendly.
 11. Intelligence estimate.
- Aspects of operation of particular interest to those monitoring the exercise:
1. Type of exercise—CPX, FTX, and characteristics.
 2. Duration of exercise.
 3. Periods of immobility.
 - a. Hour at which operations cease for the evening.
 - b. Hours spent in fixed positions—hours moving (for mobility estimate).
 4. Hours of recorded data.
 5. Nuclear weapons employment.

- a. Attempts at warning.
 - b. Size of weapons.
 - c. Ground-zero coordinates.
 - d. Units within the ground-zero effective radius.
 - e. Number of weapons used of each size.
 - f. Number of weapons available to both enemy and friendly units.
 - g. Effectiveness of nuclear weapons.
 6. Jamming.
 - a. Army Security Agency employment.
 - b. Methods used.
 - c. Hours during which jamming (real or simulated) was taking place.
 7. Friendly forces—size, type, attachments to main bodies.
 8. Enemy forces—size, type, number of units of each size and type.
 9. Phases of operation.
 - a. Hours during which each phase was taking place.
 - b. General geographical limits of phase.
 - (1) Terrain aspects of each phase.
 - (2) Vegetation.
 - (3) Trafficability—amount of off-road movement.
 - c. Type of action and result of each phase.
 10. Intelligence.
 - a. Methods used for intelligence acquisition.
 - (1) POW interrogation.
 - (2) Surveillance devices.
 - (a) Ground, real or simulated.
 - (b) Airborne.
 - (3) Ground reconnaissance.
 - (4) Air-photo coverage.
 - (5) Counterintelligence.
 11. Use of communications means other than radio.
 - a. Runner.
 - b. Wire.
 - c. Etc.
 12. Sunrise and sunset hours.
 13. Hours and coordinates at which significant events occurred; i.e., nuclear detonation, attack, retreat, etc.
 14. Necessity of relaying messages.
 - a. Manned or unmanned relay stations.
 15. Bn ↔ Co ranges.
- Background information of interest to the monitors:
1. Terrain analysis of area.
 - a. Trafficability.
 - (1) Over-all.
 - (2) Within areas in which each phase was carried out.
 - b. Vegetation concealment.
 - c. Climate of area.
 - d. Avenues of approach into enemy and friendly positions for each phase of the exercise.

e. Weather—temperature, precipitation (type, intensity, amount, effect on exercise), winds, visibility, humidity.

f. Topography.

- (1) Relief and drainage systems—effect on exercise.
- (2) Surface materials.
- (3) Influence of quality of roads, towns, bridges, airfields, fortification, etc.
- (4) Effect of terrain on observation from ground and air electronic and sonic devices.
- (5) Effect of terrain on fields of fire.
 - (a) Flat-trajectory weapon.
 - (b) High-trajectory weapon.
 - (c) Nuclear weapon employment.
- (6) Effect of terrain on concealment.
- (7) Effect of terrain on cover.
- (8) Terrain obstacles.
- (9) Critical terrain features in maneuver, coordinates, highest position.
- (10) Avenues of approach to objectives.

Comments on data gathering:

1. Time checks on the tape recordings.
 - a. Regularly spaced, every half hour.
2. Dead time accounted for and limiting times given.
3. Photos of operations overlay every half hour for duration of exercises.
 - a. Placard on overlay for each picture giving date, time (including am-pm) operations order in effect.
 - (1) Perhaps blackboard (2 by 2 ft) hung in plane of overlay giving information and coordinates of significant changes in deployment since preceding picture—or a NO CHANGE comment.
 - (a) Run test series before going to exercise and get table of acceptable orientations of lights, camera, subject.
 - (b) See that overlay is tacked down to be flush with the underlying map.
 - (c) Balance and polarize light.
 - (d) If possible keep camera in fixed positions so that plane of film is parallel to the plane of the map and the same distance from it for every shot; if this is not possible, perhaps tacks or chalk on the ground showing the positions of the fixed tripod legs would achieve the same end.
 - (e) Have lights on tripods, also, so that their orientation can be held constant.

REFERENCES

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3. Army Engineer Corps, Waterways Experiment Station, "Trafficability Survey of Selected Areas, Camp Stewart, Georgia," Misc. Paper 4-101, Nov 54. **UNCLASSIFIED**